

UNIVERSITY OF BRISTOL



THE ANNUAL REPORT

OF THE

Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL

1940

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

The Annual Report for 1939 recorded the transition in the work of the Department of Agriculture and Horticulture from normal to war-time conditions and provided some indication of the alterations in policy and programme resulting therefrom. Nevertheless, owing to the outbreak of hostilities comparatively late in that year, its contents were mainly concerned with matters in hand in the last months of peace. The present Report for 1940 differs substantially from its immediate predecessor in general character, since it relates to a period dominated throughout by the various influences of the current war and contains for the year in question a record of such sections of the Department's contribution to the national effort as can be appropriately published at this stage.

In spite of a year inevitably abnormal, the Department, at each of the constituent centres at Bristol, Campden and Long Ashton, has been able to carry through its programme considerably more closely to plan than might have been expected. With reference to the work at Campden the Annual Report of that Station, now issued separately, reveals a year of solid achievement, in which the standard and volume of its research and advisory activities have been well maintained in face of outside calls upon its Director, Mr. Hirst, and other individual members of the staff for special services. Its financial position has also remained sound. In this respect the situation at the Long Ashton Station has improved steadily throughout the year, largely owing to the increased returns from sales of produce which, in conjunction with various economies put into force previously and the increment in the block grant from the Ministry of Agriculture and Fisheries mentioned in last year's Report, enabled a deficit in the accounts for the financial year to be avoided. With the main work of the Advisory Centre at Bristol now being financed on a "deficiency grant" basis, in that case also the position has been eased administratively.

In other respects, too, both at Bristol and Long Ashton, substantial progress has been possible. The official arrangements referred to in the last Annual Report for the reservation of technical staff have enabled the research and advisory services to continue to function as efficient working units. It has not been easy to maintain a regular or adequate supply of labour and junior assistant staff throughout the period: for that and other reasons incidental to the prevailing conditions there has been at times some delay in dealing with individual items of work. In spite of such handicaps the number of enquiries received and dealt with under the Advisory Scheme established a new high record, while the Long Ashton research workers have succeeded in making important

advances, significant both for the immediate emergency and afterwards, in their investigations on horticultural food crops and products.

BERKELEY SQUARE ADVISORY CENTRE.

Staff.

Changes in staff personnel have been more numerous than usual, most being directly due to the incidence of war conditions.

Mr. H. T. Watkins, M.Sc., Assistant Advisory Chemist, terminated his appointment in October, 1940, and has been succeeded by Mr. E. L. Smith, who thus receives promotion.

Miss E. H. L. Duncan, M.A., B.Sc., Poultry Pathologist, relinquished her appointment in September, 1940, consequent on the large reduction of work in that Section of the Department necessitated by the war policy of the Government in respect of the poultry industry. Since that date advisory problems in this subject have been dealt with by the Section in charge of the Veterinary Investigation Officer, Mr. D. W. Menzies.

In the Economics Section Messrs. E. Dawson, B.Sc., N.D.A., N.D.D., and H. J. Steer, B.Sc., were appointed Technical Assistants, in April and September respectively, in succession to Messrs. P. J. O. Trist and C. W. Harwood.

An increase in the team of workers dealing with Land Fertility Surveys was sanctioned by the Ministry on account of the urgent need for extended effort under that scheme. Mr. R. O. Easdown, B.Sc., N.D.A., was therefore appointed as Fieldman under the Lime and Phosphate Deficiency Survey in October with Mr. J. M. Adams, B.Sc., N.D.D., as Assistant Fieldman. A second Assistant, Mr. W. Metcalfe, B.Sc., N.D.A., N.D.D., was also appointed the following month.

LONG ASHTON RESEARCH STATION.

Staff.

There have been few changes in staff during the year. Mr. H. Locke, Station Guide and Meteorological Recorder, retired from that post at the end of July, 1940, having reached superannuation age. He has been in the service of the Station since 1916, when he joined the staff as Plantations Foreman. When changes were made in the Plantations organisation in 1927, he took over the duties which he now relinquishes. As one of the few remaining members of the staff whose services date back to the last war, he has participated in the very considerable development of the Station and its work which has occurred since that time and has contributed in no small measure to the close and cordial relations which have been established with horticulturists in the West of England particularly. In view of the loss of other members of the recording staff owing to the calls of national service, arrangements have been made for his part-time assistance in the recording and advisory work.

The Fruit Products Section has been strengthened by the addition of Mr. A. Pollard, M.Sc. (Lond.), Ph.D. (Manchester), as Research Biochemist, and of Mr. D. P. Hopkins, B.Sc. (Lond.), in February, 1940. The duties

of the latter are concerned primarily with the processing operations associated with the investigations on fruit products. In the same Section Miss M. E. Kieser, B.Sc. (Bristol), was appointed in June, 1940, as Analyst, succeeding Miss O. M. Hands, B.Sc. (Lond.), who held that appointment for a few months earlier in the year. In the Plant Nutrition Section, Mr. W. Plant, Ph.D. (Reading), succeeded Mr. A. Alcock in August, 1940, as Assistant in General Chemistry.

In view of the considerable development of the work of the Station in connection with Domestic Preservation of Fruit and Vegetables the Ministry of Agriculture has sanctioned the appointment of an assistant to Miss B. A. Crang, the head of that Section. Miss Marjorie Jones, Dip. Hort. (Studley), has been given this appointment and further additions to this Section are foreshadowed for 1941.

The Mole Destruction experiments undertaken by the Department at the request of the Ministry of Agriculture are being continued. Mr. S. H. Bennett, B.Sc. (Bristol), was engaged on these experiments and an investigation on Wireworms during the greater part of the year, and was then transferred to a newly-established post as Assistant Advisory Entomologist, Mr. N. G. Morgan, B.Sc. (Bristol) replacing him in charge of the Mole Destruction experiments. The Advisory Staff has been further increased for the special investigations on Wireworm problems. The work is under the general charge of Dr. C. L. Walton, Senior Advisory Entomologist, with whom Mr. S. H. Bennett was collaborating until October, 1940, when the wireworm section of his work was taken over by Mr. L. E. W. Stone, A.R.C.S., B.Sc. (Lond.), and Mr. A. Stringer, A.R.C.S., B.Sc. (Lond.).

These additions to the staff are primarily to meet war-time needs. Several members of the permanent staff are actively participating in outside work with Government Departments and other public bodies, as recorded in the Annual Report for 1939.

Buildings and Land.

No addition has been made to the buildings at the Station during the year but, as far as possible, attention has been given to the necessary property repairs and maintenance referred to in the Report of last year. Part of the necessary repairs to boundary walls and fences on the property has been completed and the remainder of this work is being proceeded with as opportunity allows.

The necessary changed policy in respect of the work in the plantations and nurseries has been pursued during the year. In certain cases material for field experiments had been in preparation in the Station nurseries before the war, but the plantings cannot be made under current Ministry regulations. Such cases involve financial losses, since the nursery trees cannot be disposed of, but increased crop production from the plots of ground cleared may counterbalance such losses.

The research programmes concerning plant breeding and root stocks have been substantially curtailed, so making possible the grubbing of

some uneconomic field plots. Manurial experiments on raspberries and strawberries have been terminated and the land utilised for experiments on vegetable culture.

The general policy of cropping all plots with potatoes and vegetables after clearance from fruit has been adopted.

Experiments on vegetable culture have been initiated and comprehensive schemes of manurial experiments commenced at Long Ashton and in the Vale of Evesham. The experiments are linked up with the work on vegetable pathology carried out under the direction of Mr. Ogilvie, the Adviser in Economic Mycology.

An official Order having been received to plough 8 acres of grassland on the section of the farm not occupied with fruit and vegetable culture, Mr. A. W. Ling, Chief Agricultural Advisory Officer, in whose charge the farm operations have been placed, has found it necessary to adapt the farm policy in respect of live stock to meet the altered situation.

Research Activities.

As previously reported, the work of the Station since the outbreak of the war has been modified in certain ways in order to give attention to special war-time problems and for economic reasons. In particular, long-period research projects, with little likelihood of immediate practical application, have been suspended. The individual articles contained in this year's Report relate to some of the results of the altered programme. In certain cases no specific detailed references have been made to investigations in progress and, accordingly, brief mention of the work of the Sections concerned will be made at this point.

In Plant Pathology the programme of field experiments on fruit in commercial plantations have been greatly curtailed.

The comprehensive scheme of Fruit Storage investigations previously followed has been suspended and attention has been given to urgent problems of quality which arise under war-time conditions.

Much of the work in the Fruit Products Section during the year has been in collaboration with officers of the Ministry of Agriculture, the Ministry of Food and the Department of Scientific and Industrial Research. Its programme has assumed considerable importance under existing conditions, in view of the need for avoiding wastage of crops. It is being extended to cover also, where necessary, the case of surplus vegetable produce.

The Section dealing with the Domestic Preservation of Fruit and Vegetables has been very fully occupied with work arising largely from the special efforts made by the various Government Departments in association with Women's Institutes and local organisations to encourage the preservation of home-grown produce at local centres and in the home. The results arising from the experimental work concerned therewith have been made use of extensively in the Growmore Bulletin No. 3 of the Ministry of Agriculture and Fisheries, which has been prepared by

Miss Crang, the head of the Section, in collaboration with Miss M. Mason, of the technical staff of the Ministry. A wide extension of home preservation of crops has made it particularly necessary to ensure that a sufficient number of trained Supervisors and Demonstrators are available to serve the numerous centres seasonally engaged in preservation operations. Accordingly, in addition to the usual annual courses of instruction, a special Conference and Refresher Courses for Instructresses were organised by the Section during the year.

General.

Annual Field Day. It was decided not to arrange a function on the lines of the usual Annual Field Day while war conditions prevailed. In its place the occasion of the Annual Meeting of Members of the National Fruit and Cider Institute at the Station on Thursday, June 27th, provided a convenient opportunity to open the Station to visitors and to demonstrate the field work in progress and the results of the cider-making experiments of the season 1939-40.

Advantage was also taken of this occasion to present the McCreath Cup to Mr. John W. Pullin, representing Messrs. Pullin Bros., Compton Greenfield, Glos. This trophy was offered by Mr. W. D. McCreath, of North Petherton, Somerset, to the exhibitor obtaining the highest aggregate awards in Open Cider Competitions during the period 1937-1939 inclusive.

Visitors. Although the number of individual visitors to the Station has been less than in normal years, the falling-off noticeable in the first months of the war was less marked as the year proceeded. The Station and the Bristol Agricultural Advisory Centre were visited by the Minister of Agriculture and Fisheries, the Rt. Hon. R. S. Hudson, P.C., M.P., in November, while during the course of September a group of members of the Royal Norwegian Government, including the Norwegian Minister of Agriculture, also came to the Station to view the work in progress.

The following organised parties were also received at the Station during the year :—

Fishponds Diocesan Training College Students.
 King's College, (London), Engineering Society.
 Bristol Camera Club.
 Instructional Conference on War-time Domestic Preservation of Horticultural Crops.
 Long Ashton School.
 King's College, (London), Geographical Association.
 Georgian Old Boys' Society.
 Yeovil Young Farmers' Club.
 St. George's, (Bristol), Air Raid Wardens.
 Reading University Students.
 Ashton Gate Division Auxiliary Fire Service.
 Nailsea Women's Institute.
 Clifton College Scientific Society.
 Ashton Gate Branch of British Legion.
 Bristol Tramways & Carriage Co., Ltd., Constructional Works Section.
 Imperial Airways Catering Department.
 Bristol Folk House Members.
 University Chemical Society.

Research Students and Voluntary Workers. As anticipated, the succession of post-graduate research workers at the Station has not been maintained on account of the unsettled international situation. During the year the following have pursued investigations at Long Ashton :— Mr. A. F. Parker-Rhodes, B.A., Dip.Agr., and Mr. M. I. Shah, M.Sc.

Acknowledgments.

Although the prevailing conditions throughout the year have caused many unavoidable changes in the nature of the services of the Department and of its contacts with the various industries, organisations, and individuals coming within the range of its activities, the same willing co-operation and support characteristic of more normal times have been met with on all sides. For such help, financial and otherwise, the Department tenders its grateful appreciation to all concerned.

Despite the increased personal anxieties and additional heavy claims on their own time affecting all grades of staff, they have continued to carry out their departmental duties in a manner calling for a special word of acknowledgment and thanks.

A PRELIMINARY NOTE ON THE COMPARATIVE EFFECTS OF SULPHATE OF POTASH, MURIATE OF POTASH AND KAINIT ON VARIOUS FRUIT PLANTS.

By T. WALLACE and D. A. OSMOND.

In practically every experiment carried out in this country with potash fertilisers on fruit crops, sulphate of potash has been used as the source of potash, and this form of potash has been generally recommended for fruit manuring in view of its known effectiveness and a knowledge that injurious effects from the use of chloride-containing materials have been recorded in commercial practice in this country and in experiments carried out on bush fruits, mainly on the Continent.

Hoblyn (1) at East Malling obtained results on raspberries, variety Lloyd George, from which he concluded that kainit was less effective than sulphate of potash and appeared to have harmful effects in some seasons.

In continental experiments (see Refs. in 2) red currants have been shown to be very susceptible to chlorine injury whilst black currants are relatively resistant. Gooseberries have also responded better to sulphate than to muriate of potash.

In view of the lack of data for various fruits in this country, a plot was established at Long Ashton in January, 1938, to compare the effects of sulphate and muriate of potash and of kainit on apples, gooseberries, raspberries, red currants and black currants.

The plot has now had two seasons of the differential manurial treatments, and as certain points are already showing, which are of particular importance under war-time conditions, it has been considered desirable to record these, although it must be emphasised that the conclusions are to be regarded as tentative and subject to revision as further data become available in future seasons.

The important practical indication from the results is that chloride-containing potassic fertilisers are likely to be effective sources of potash for apples and black currants, and without the likelihood of producing chlorine injury. On the other hand, these fertilisers appear unsuitable for red currants, and there may be some risk in their use for gooseberries and raspberries, although the evidence in the latter two cases is not yet very clear.

Experimental

The area on which the experimental plot is situated formed part of an old meadow until March, 1934, when it was ploughed up and subsequently cropped with a rotation of vegetable crops, without manure of

any kind, until 1937. This cropping programme was carried out to impoverish the soil and to ensure potash deficiency conditions for the fruit at planting time.

The soil is a fine sandy, light loam with free drainage.

The plot is a composite plant, all planting being carried out in January, 1938.

Apple trees are planted at 18' square and the various bush fruits and raspberries are interplanted in the tree rows and in the alleyways to give a planting of 6' $\times$ 6'. The planting is so arranged that the various bush fruits are in rows, giving a balanced layout on each sub-plot.

The details of the trees and bushes used are as follows:—apples, variety Cox's Orange Pippin on Malling No. II rootstock, planted as 2-year olds; gooseberries, variety Keepsake, planted as 2-year olds; raspberries, variety Preussen; red currants, variety Seabrook's Black, planted as 2-year olds. On each sub-plot there are 8 apple trees, 16 bushes each of gooseberries, red currants and black currants and 24 stools of raspberries, except under treatment E, where there are only 8 apple trees and no bush fruits. The various kinds of plants have had ordinary commercial treatment.

The differential manurial treatments are as follows:—

<i>Treatment A.</i>	Nitro chalk,	superphosphate,	kainit.
<i>Treatment B.</i>	" "	" "	muriate of potash.
<i>Treatment C.</i>	" "	" "	sulphate of potash.
<i>Treatment D.</i>	" "	" "	no potash (arable cultivation).
<i>Treatment E.</i>	" "	" "	" (grass culture).

Treatments A, B and C are in duplicate, but D and E are only single plots. The rates per acre of the various fertilisers in all cases are: nitro chalk, 2 cwt.; superphosphate, 3 cwt.; and potash fertilisers at rates equivalent to 3 cwt. sulphate of potash.

The dressings are applied annually in early March and so far have been given in 1939 and 1940. No manure was given in 1938.

Results and Discussion.

The data for discussion are given in Tables I—III below. They refer to observations made on the condition of the plants on the various plots on August 30th, 1940, during the second season of the differential manurial treatments and to the potash and chlorine contents of the leaves of current season's shoots in early September, 1940.

In considering the data it should be pointed out that at this early stage of the experiment there are, of course, some irregularities in the responses shown by the individual plants on the various plots which no doubt will be smoothed out as the experiment progresses, but in spite of these the data seem to show certain well-defined trends due to the treatments, which require bringing to the notice of growers at the present time.

TABLE I.
NOTES ON GROWTH AND FOLIAGE, AUGUST 30TH, 1940.

Potash Treatment.	Apples.		Gooseberries.		Raspberries.		Red Currants.		Black Currants.	
	Shoot Growth.	Leaf Scorch.	Shoot Growth.	Leaf Scorch.	Shoot Growth.	Leaf Scorch.	Shoot Growth.	Leaf Scorch.	Shoot Growth.	Leaf Scorch.
Kainit A 1	Excellent.	Trace.	Fairly good.	Trace.	Variable.	Slight to very slight.	Good.	Medium.	Good.	Nil.
	Very good.	Nil.	Fairly good.	Slight.	Variable. Moderate to poor.	Slight.	Moderate.	Medium to medium-severe.	Fairly good to moderate.	Nil.
Muriate B 1	Excellent to very good.	Slight to very slight.	Fairly good.	Trace.	Variable.	Very slight.	Fairly good.	Medium.	Good.	Nil.
	do.	Slight to trace.	Fairly good but variable.	Slight.	Moderate.	Slight	Fairly good	Medium to medium-severe.	Good.	Nil.
Sulphate C 1	Very good.	Medium to very slight.	Good to fairly good.	Variable. Slight to nil.	Variable.	Very slight.	Good.	Slight to nil.	Good.	Nil.
	Excellent to good.	Slight to trace.	Fairly good but variable.	Slight.	Variable.	Very slight.	Good.	Slight to nil.	Good.	Nil.
No Potash.										
Arable D	Very good.	Mainly medium.	Variable. Fairly good to poor.	Variable. Severe to slight.	Moderate to poor.	Generally medium.	Generally moderate to poor.	Severe to medium (Grey margins).	Variable. Fairly good to moderate.	Variable. Medium to very slight.
No Potash. Grass E	Very good to good.	Very slight.	—	—	—	—	—	—	—	—

TABLE II.

SHOWING PERCENTAGES OF POTASH IN DRY MATTER AND PERCENTAGE INCREASES IN POTASH DUE TO POTASH MANURING IN THE VARIOUS FRUITS—LEAF SAMPLES, SEPTEMBER 1940.

Potash Treatment.	Apples.		Gooseberries.		Raspberries.		Red Currants.		Black Currants.	
	% K ₂ O in Dry Matter	K ₂ O as % in No Potash Sample	% K ₂ O in Dry Matter	K ₂ O as % in No Potash Sample	% K ₂ O in Dry Matter	K ₂ O as % in No Potash Sample	% K ₂ O in Dry Matter	K ₂ O as % in No Potash Sample	% K ₂ O in Dry Matter	K ₂ O as % in No Potash Sample
Kainit ..	1.33	173	2.36	148	1.06	147	1.39	309	1.27	135
Muriate ..	0.95	123	1.81	114	1.10	153	0.99	220	1.18	126
Sulphate ..	0.71	92	1.90	120	0.94	131	1.08	240	1.10	117
No Potash Arable ..	0.77	100	1.59	100	0.72	100	0.45	100	0.94	100
No Potash Grass ..	0.78	101	—	—	—	—	—	—	—	—

TABLE III.

SHOWING PERCENTAGES OF CHLORINE IN DRY MATTER AND PERCENTAGE INCREASES IN CHLORINE DUE TO POTASH MANURING IN THE VARIOUS FRUITS—LEAF SAMPLES, SEPTEMBER 1940.

Potash Treatment.	Apples.		Gooseberries.		Raspberries.		Red Currants.		Black Currants.	
	% Cl in Dry Matter	Cl as % in No Potash Sample	% Cl in Dry Matter	Cl as % in No Potash Sample	% Cl in Dry Matter	Cl as % in No Potash Sample	% Cl in Dry Matter	Cl as % in No Potash Sample	% Cl in Dry Matter	Cl as % in No Potash Sample
Kainit ..	0.15	79	0.45	161	1.09	248	2.00	377	0.61	87
Muriate ..	0.12	63	0.39	139	0.88	200	1.54	291	0.63	90
Sulphate ..	0.12	63	0.27	96	0.41	93	0.77	145	0.58	83
No Potash Arable ..	0.19	100	0.28	100	0.44	100	0.53	100	0.70	100
No Potash Grass ..	0.17	90	—	—	—	—	—	—	—	—

In Table I observations on shoot growth and the incidence of leaf scorch for the various classes of plants on the different plots are presented in summarised form. The main points arising are as follows:—

Apples. Shoot growth was either very good or excellent on all arable plots and was somewhat less on the grassed plot. All the potash treatments appeared to have decreased the amount and severity of marginal leaf scorch and the results from kainit and muriate were, if anything, superior to those from sulphate.

Gooseberries. Growth in this case was variable on most plots and scorch effects were also inclined to show variation, but it was quite clear that all potash treatments had proved very effective.

Raspberries. Growth on all plots was very variable, but on all potash treated plots there were to be found some very vigorous shoots. The “no potash” plot was well behind the others in growth and showed much more scorching.

Red Currants. The results with this fruit were outstanding, in that the sulphate treatment produced results quite different from those on the muriate and kainit plots. All potash treatments showed great

improvement over the "no potash" treatment, where the bushes were stunted, the leaves small and showing a severe "ashy grey" marginal scorch. Scorch was generally very slight on the sulphate plots, but was considerable on the muriate and kainit plots. The scorched leaf margins on the treated plots were brown in colour and not grey as on the "no potash" plot. The result for this fruit leaves no doubt as to the superiority of the sulphate treatment.

Black Currants. Growth was good and scorch absent on all the potash-treated plots, and all treatments seemed to have been equally effective in controlling the deficiency.

Table II gives an indication of the way in which the potash treatments have raised the potash contents of the leaves and thus of the extent to which they have remedied any deficiency which existed. In considering the data it may be stated that for most fruit plants examined values for potash below 1.00% in the dry matter of leaves have generally denoted a deficiency in potash.

In the case of the apples no significant effect is shown from sulphate treatment whilst kainit and muriate seem to have been definitely more effective.

In the gooseberries, the value for the "no potash" plot does not indicate any material deficiency, but it must be pointed out that growth and scorch for this plant is very variable on the "no potash" plot and that the most severely affected bushes were practically defoliated so that the leaf samples represented the best bushes rather than the poorer ones on the plot. Here again kainit treatment is associated with the highest potash value in the leaves.

With raspberries the "no potash" plot value indicates a definite deficiency and all treatments have raised the potash content to a point bordering on a condition of sufficiency.

The red currant values show a remarkable rise in potash content due to the manures, from a very low and typical deficient value on the "no potash" plot to a value for kainit which should be above a deficiency level. It should be noted that the sulphate level is decidedly below that for kainit although the sulphate plants show much less scorch.

In the case of the black currants all treatments have raised the potash from a deficiency level to values where the bushes are free from scorching, kainit being the most effective and sulphate apparently the least.

It should be noted in considering all these results that kainit has invariably given a higher potash value than sulphate, even in the case of red currants where the visual effects are much superior for the latter treatment.

Table III, presenting the results for the chlorine contents of the leaves, brings out two important points, viz.:—(1) that the use of chloride-containing materials may substantially increase the chlorine contents of leaves; (2) that the fruit plants considered are not affected in the same way.

Thus the chlorine contents of red currants, raspberries and gooseberries have all been greatly increased by kainit and muriate treatments, and it seems quite possible that all three may be eventually injured by this, as the field results for red currants already suggest.

In the case of the gooseberries the chlorine content from kainit treatment, although greatly increased over that on the "no potash" plot, is still low.

Again, it is clear that for apples and black currants the chlorine contents of the leaves have not been increased by the kainit and muriate treatments, and hence it may be assumed that chlorine injury is unlikely to occur readily in these fruits.

A further point shown in the chemical data, but not reported here, is that kainit, which contains a high proportion of sodium chloride, has not raised the sodium content of the leaves to any appreciable extent.

Conclusions.

Considering the results as a whole the following conclusions would seem justified :—

1. All potash treatments have proved effective in decreasing the initial potash deficiency and may be expected in due course to overcome it completely.

2. Kainit and muriate have not proved inferior to sulphate of potash in supplying potash for the various plants, kainit perhaps being the most efficient.

3. Kainit and muriate have increased the content of chlorine in the leaves of red currants, raspberries and gooseberries, especially the first of these, and may raise it to injurious levels resulting in a form of marginal scorch similar in appearance to that due to potash deficiency.

4. The chlorine contents in apples and black currants have not been raised by kainit or muriate treatments, and it would seem that these fruits would not suffer readily from chlorine injury from the use of chloride-containing materials.

In conclusion, one final point must be made. There is always a possibility of injury occurring from the careless application of kainit or muriate of potash to bush fruits when these fertilisers are in a wet condition. Such injury should not be confused with the so-called chlorine-injury discussed in this paper.

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A NOTE ON MANGANESE DEFICIENCY IN AGRICULTURAL AND HORTICULTURAL CROPS.

By T. WALLACE.

Manganese is now generally regarded by plant physiologists as one of the elements necessary for many plants to complete their cycles of growth. It is thus placed in the group of essential nutrient elements but, being required only in very small quantities by the plants, it is referred to as a "minor" element to distinguish it from elements such as nitrogen, phosphorus, potassium and calcium, which are required in much larger amounts and which are designated "major" elements.

Deficiency of manganese in plants is not only of academic interest, but is of considerable economic importance in agricultural and horticultural crops.

The deficiency has been reported in various crops, particularly oats, in Australia, North America and Europe, and many cases, although not as yet involving large areas, have been noted in this country during recent years.

The more notable cases which have been under observation in England are located as follows:—Romney Marsh; The Fens, including parts of Cambridgeshire and Lincolnshire; the West Midlands, including Warwickshire, Staffordshire and Shropshire; Lancashire, Derbyshire, Somerset and Bristol. It will be seen that the deficiency is of more than local interest, and as the symptoms of the trouble become better known to farmers there is no doubt that it will be recognised as a factor of some importance.

The cases already recorded have generally been confined to small acreages, but they have indicated the importance which the deficiency could assume under certain circumstances in areas such as the Fens.

Soil Conditions in Cases of Manganese Deficiency.

A study has been made by members of a Sub-Committee of the Advisory Chemists Conference of the Ministry of Agriculture and Fisheries of the soil conditions and manurial practices in the cases of manganese deficiency occurring in the districts listed above.

As a result of this it has been possible to group the soils into a number of categories and to indicate the particular conditions which are conducive to the development of the deficiency. The investigations have also shown that manganese as an element is not deficient in the soils in an absolute sense, but is unavailable to plants because of certain conditions which may have developed naturally in the soils or which may have been artificially created by the farmer or grower.

The special soil conditions associated with the deficiency may be grouped as follows :—

1. Thin peaty soils overlying calcareous subsoils, *e.g.* the “Skirt” soils of the Fens.
2. Calcareous Silt Clays, *i.e.* alluvial soils derived from calcareous materials such as the Lower Lias Clay.
3. Poorly drained calcareous soils with high contents of organic matter, *e.g.* wet patches of soil on the Carboniferous Limestone Formation.
4. Reclaimed Heath Soils, subsequently limed too generously.
5. Calcareous soils freshly broken up from old grassland.
6. Old black garden soils where stable manure and lime have been applied regularly for many years.

The two conditions common to all cases are a high content of organic matter and a high lime status (pH above 6.5), and it seems that, given a combination of these two conditions, the manganese in the soil may be rendered unavailable to certain plants.

A knowledge of the soil conditions conducive to the trouble is of great importance to farmers and growers, especially at the present time. In the first place it is important to know the “natural” conditions under which the trouble may occur as poor results and failures can often be avoided by suitable cropping. Secondly, at the present time when a national liming campaign is in full swing it is of importance to note that black sandy acid soils, the typical soils of old heaths, may be damaged by over-liming. This of course does not mean that such soils should not be limed; indeed they must be limed to produce remunerative crops, but liming must be carried out intelligently and if necessary the guidance of the Provincial Advisory Chemist should be sought.

Thirdly, the fact that old grassland on calcareous soils when broken up may produce the conditions conducive to the trouble is important. Fortunately in the Bristol province the main types of soil liable to be associated with such failures have been surveyed and advice can already be given.

Fourthly, the cases occurring on old black garden soils are of special importance to market gardeners and to allotment holders who may have taken over land on old garden sites, and are of special interest in the Bristol area.

Susceptible Crops.

Among agricultural crops the oat crop appears the most sensitive to the deficiency and may fail entirely. The trouble in this crop is generally known as “Grey Speck” disease. The plants become affected at a relatively early stage, the leaves of the young plants first becoming somewhat pale, then showing greyish spots midway along their lengths, which gradually develop into streaks, after which stage the leaves break

over near the middle and subsequently become yellow and die. The root system is poorly developed. Grain may fail to develop where the plants continue to exist in a weak state.

Other highly susceptible crops are sugar beet and mangolds, where the condition is known as "Speckled Yellows," because of the characteristic colouring of the leaves. Here again the leaves of the young plants become pale, and then whitish or yellowish patches develop between the veins. The affected patches frequently turn brown and die and the dried tissue may fall out. The leaves tend to become erect, the edges turn inwards towards the upper surfaces, the shape thus appearing narrow and triangular in outline. Peas may also be severely affected, but in this case no symptoms may be apparent on the foliage, but the cotyledons of the seeds show brown markings in their centres, the condition being known as "Marsh Spot."

Other crops which are affected but generally less so than the above are wheat, barley and potatoes. The symptoms on wheat and barley differ in detail from those of oats, but the eventual yellowing of the leaves occurs. Potatoes usually develop their special symptoms near the flowering period. The tip leaves of the plants become slightly pale and small brown spots develop along the central and lateral veins.

Observations on horticultural crops have been almost wholly confined to the Bristol district where by far the most susceptible crop appears to be the globe beet root. The symptoms are similar to those of sugar beet, but the affected leaves lose their green colour and become abnormally red. Long varieties of beet, *e.g.* Cheltenham Green Top, appear much less susceptible than the globe sorts. Spinach and spinach beet are both highly susceptible and show typical chlorotic mottling of the leaves. Other vegetables noted as affected are parsnip (chlorotic mottling of foliage), parsley (browning of edges of leaves), cos lettuce (chlorosis and edge scorching of older leaves), onions (white streaking of leaves), dwarf and runner beans (slight chlorotic mottling of leaves), vegetable marrow (chlorotic mottling of the leaves).

Among fruits, apples and raspberries have both shown intervenal chlorosis of the leaves, in raspberries the leaves of fruited canes being more affected than the young new seasonal growths.

In the case of all crops it has been noted that there may be a considerable amount of natural recovery of plants which survive the early stages of growth late in the season.

The Occurrence of Manganese Deficiency in the Bristol Province.

The failures of agricultural crops in the Bristol Province have been confined entirely to areas of newly-ploughed out old grassland, and in all cases except one the soil is derived from calcareous Silt Clay material (alluvial) or calcareous Grey Clay with Soft Limestone (colluvial). The exception is a soil derived from calcareous Red Clay over Hard Limestone through which ground water seeps from the limestone rock. The pH in all cases ranges from 6.6 to 7.0.

The conditions conducive to the trouble in all cases would thus appear to be a high organic matter content, due to the old grass, a high pH, due to the calcareous nature of the soil parent materials, and the presence of ground water which seems to lead to the deposition of manganese in the form of manganese dioxide.

The chief areas affected are situated in Somerset on the low-lying portions of the area bounded by Bridgwater, Weston-super-Mare, Congresbury and Wedmore. In all cases but one the affected crop was oats, the exception being mangolds.

The soils on which the deficiency occurs in the above area have been classified as the Puxton Series. A survey of soils on other series where the trouble might have been expected was made—Evesham, Haselor, Worcester, Somerton and Taunton Series—but no cases on these were found.

Of the failures noted in horticultural crops all excepting one, which occurred on an allotment area near Weston-super-Mare on the Puxton Series, were undoubtedly induced by special manurial practices, namely the use of heavy dressings of poor quality town stable manure and excessive liming. The main area affected is situated in Bristol on soils derived from the Pennant Sandstone Formation.

Before use for intensive garden culture these soils, which are of a light sandy nature, are red in colour, due to staining from Triassic wash, only moderately supplied with organic matter and devoid of carbonate of lime. In this state, on new garden sites, manganese deficiency has not been observed. After long usage for market garden purposes the soils are black, well supplied with carbonate of lime, with pH ranging from 6.6 to over 7.0, and here the deficiency is present to a greater or lesser extent on susceptible crops in most gardens.

Two other cases are of interest. One is on a plot at Long Ashton—soil Worcester Series—which was limed for vegetables in the winter of 1939-40 to a pH of 6.8. Globe beets were affected on this plot. The other case is in an area of allotments in Bristol established on an old ash tip with which is mixed miscellaneous earthy waste material including mortar rubble. Here also globe beet was a failure due to the deficiency.

Control Measures.

There are several methods of avoiding or overcoming the bad effects of manganese deficiency. These may be stated as follows:—

1. Avoid growing highly susceptible crops such as oats, sugar beet, mangolds, garden beet, peas, spinach and spinach beet.

The avoidance of oats on newly-ploughed grassland is of importance on soils such as the Puxton Series. Wheat would be more likely to succeed.

2. Good quality farmyard manure will control the trouble in the year of application, but the residual value for this purpose for subsequent crops appears to be very small. This would be a very suitable method for potatoes and root crops.

3. Dressing with finely ground sulphur at rates from 5 cwts. to 1 ton per acre has given excellent results on various crops, including oats, wheat, barley, sugar beet, mangolds, and potatoes. It acts by lowering the pH of the soil (*i.e.* as an acidifying agent).

Sulphate of ammonia used in this way has not given good results.

Under war conditions sulphur will not be available for this purpose on a large scale though possibly it might be used for small areas in gardens, glasshouses, etc.

Where manganese deficiency is due to overliming, on theoretical grounds, 1 ton of sulphur should serve to counteract the effects of 3 tons of carbonate of lime.

4. Basic slag, owing to its content of manganese, has given beneficial effects in one experiment on mangolds and sugar beet but not on oats. It cannot be recommended on present evidence for general use.

5. Manganese sulphate has given excellent results on various crops, used either as a fertiliser at sowing time, at a rate of 1 cwt. per acre, or as a spray or dust on the foliage of the young plants at rates ranging from 20 to 60 lb. per acre. One case is reported on sugar beet of control from two sprayings of 2.5 lb. each of manganese sulphate per acre.

Two drawbacks to the use of manganese sulphate are its cost and the fact that residual effects for later crops generally appear to be negligible, and hence an application is necessary for each crop.

Trials are to be made with manganese chloride and ground manganese ores as substitutes for manganese sulphate.

It should be added that the control of the trouble in market garden crops, where spraying or dusting machines are available, should be quite simple. Excellent results have been obtained from sprays of manganese sulphate on severely affected crops in Bristol gardens, including the highly susceptible globe beet.

In conclusion, it may be stated that if growers will learn to recognise the symptoms of manganese deficiency and the conditions under which it is likely to occur, it is not likely to lead to appreciable losses since effective methods of treatment are known and can usually be successfully applied if measures are taken at an early stage.

Where doubts exist growers in the Bristol Province are advised to get in touch with the staff of this Station.

Acknowledgment.

Messrs. L. Ogilvie, J. O. Jones, H. E. Croxall and Dr. D. A. Osmond are associated with the writer in investigations in the Bristol Province.

MAGNESIUM DEFICIENCY OF FRUIT AND VEGETABLE CROPS.

By T. WALLACE.

As long ago as 1840 Liebig, on the basis of ash analysis of plants, considered magnesium to be an essential element in plant growth, and since that time, though much attention has been given by chemists and physiologists to the "magnesium problem," there has been little agreement as to the necessity of applying magnesium-containing materials in general farming practice.

The extensive field experiments of Brioux* in France are typical of many attempts which have been made to settle the problem, but after much work he could only conclude that the trials merely served to demonstrate that in many soils the supplies of available magnesium are sufficient for the needs of many agricultural crops.

Following the work of Loew, which centres round the ratio of lime to magnesia in plants, the idea of magnesium toxicity came into prominence, which in this country was supported by results obtained on potatoes at Woburn and the experience of farmers in the use of burnt magnesian lime, which if left about in heaps on fields may result in sterile patches.

The idea of magnesium toxicity was also strengthened by the knowledge of the relative infertility of soils derived from rocks of high magnesium content, such as Serpentine, but these poor results have been shown to be possibly due to factors other than magnesium.

Whilst the functions of magnesium in plant growth are not wholly understood, one function alone, discovered by Willstätter, namely, that magnesium is an essential ingredient of the chlorophyll molecule, the green colouring matter of leaves, marks it out as of fundamental importance to all green plants.

In spite of this fundamental rôle of magnesium in the growth of plants, the fact that in the past deficiency of the element has not been established to be widespread points to the conclusion that at least under older systems of farming there was not usually a special need for the application of magnesium as a fertiliser.

During the past twenty years, however, numerous cases of magnesium deficiency of special crops have been reported from various parts of the world, and the writer has shown recently that the deficiency has become of common occurrence in fruit plantations in this country. Moreover, during 1940 an outstanding case of the trouble in vegetable crops was recorded at Long Ashton.

* See Ref. 1 at end of this paper for accounts of and references to previous work.

These recent developments appear to make it desirable to bring the main practical aspects of the deficiency to the notice of fruit and vegetable growers.

Occurrence of Magnesium Deficiency.

The main areas from which the deficiency has been reported are : - The Eastern States of the U.S.A. and Canada ; Germany, Holland, Belgium and Bohemia ; New South Wales and New Zealand. The soils on which the disease occurs are always of the leached, sandy types, naturally poor in the soil bases, lime, magnesia and potash.

The chief crops affected are :—U.S.A., tobacco, cotton, potatoes, corn, buckwheat and various vegetables ; Canada, potatoes (apples have also been reported) ; Germany, sugar beet (also pine trees “Yellow Tip” disease) ; Holland, cereals especially oats (the deficiency is known as “Acidity Disease”) ; Belgium and Bohemia, sugar beet and cereals ; New South Wales, citrus and vegetables ; New Zealand, apples.

The classical case of the deficiency in the U.S.A. is tobacco, in which crop the trouble is known as “Sand Drown,” due to the facts that it is prevalent on sandy soils and is always most serious in wet seasons. The deficiency has very serious effects on this crop, where the quality of the leaf is all-important.

Symptoms of the Deficiency.

The symptoms of the deficiency shown by different plants are very varied in detail, although there are certain features common to all. Leaf symptoms are always the most valuable, and it is absolutely essential to become familiar with these for the various crops to detect the onset of the trouble.

Leaves of affected plants always show some of the following points :—Intervenal chlorosis often followed by necrosis of the affected tissue : high colourations, generally yellows, reds and purples and often of well-defined outline : marginal browning or browning of patches near the centres of the leaves. The symptoms invariably appear first on the oldest leaves and develop progressively up the shoots to the young foliage at the tips. Affected leaves tend to be shed prematurely and often only the youngest tip leaves are retained as the growing season advances. This severe defoliation is an outstanding feature of the deficiency. In the early stages growth may not be materially checked, but in the later stages and especially in perennial plants considerable dwarfing may occur.

Experience with tobacco and fruit plants has shown that for these crops diagnosis of the deficiency can be confirmed by chemical examination of the leaves of the plants. In both of these cases it has been found that where the leaves are from healthy plants the magnesia (MgO) content in the dry matter of the older leaves is 0.40% or over, whereas in cases of the deficiency the value is below 0.40% and may be as low as 0.20% MgO. Doubtless this method can be applied to any crop, the critical level for MgO requiring to be determined in each case.

Control Measures.

Magnesium deficiency can be readily controlled by appropriate soil treatment, and for this purpose there are two classes of magnesium-containing materials available, the slower-acting, insoluble magnesian limestone, which contains magnesium carbonate, and the quicker-acting, soluble magnesium sulphate materials. The latter group comprises Epsom Salts (a hydrated form of magnesium sulphate), calcined kieserite (an hydrous magnesium sulphate), and sulphate of potash-magnesia (a mixed product containing both sulphate of potash and sulphate of magnesia).

It should be noted that present-day kainit does not contain appreciable magnesia and is useless against the deficiency.

The value of magnesian limestone for the control of magnesium deficiency lies in its content of magnesium carbonate, and as this is very variable the content of this ingredient should invariably be ascertained before purchase. Low grade materials, containing less than 20% MgCO_3 should not normally be used. Magnesian limestone, in addition to supplying magnesium, also neutralises soil acidity and thus performs the functions of an ordinary lime dressing. It is thus particularly suited for cases of magnesium deficiency occurring on acid soils.

Where quick responses are required, as may happen in vegetable culture, the soluble sulphate materials are generally preferred to the limestone, though in such cases a mixture of the two materials will ensure a lasting supply of magnesium as well as a supply for immediate needs.

Magnesian limestone should be used in a similar way to ordinary ground limestone, and dressings of 1 to 2 tons per acre, to last for several years, will be adequate. For vegetables, sulphate dressings to supply 20-30 lb. of MgO per acre are usual in the U.S.A., and should prove suitable in this country. During the war, growers will have to rely almost wholly on magnesian limestone, as the main sources of magnesium sulphate for agricultural purposes, calcined kieserite and sulphate of potash-magnesia, are German products.

In addition to the above materials, good quality stable manure will supply sufficient magnesium for the needs of most crops and some magnesium may also be derived from crop residues and composts.

So far, experiments at this Station on the control of magnesium deficiency by soil treatments have been confined to fruit—apples, black currants and gooseberries. The results have shown that neither magnesian limestone nor magnesium sulphate produce observable effects during the first season of treatment even when dressings as heavy as 5 cwt. per acre of calcined kieserite (containing 30% MgO) are used. During the second season marked results have been apparent from the sulphate dressings, and less obvious effects have been produced by the slower-acting limestone.

Final recommendations as to the best rates of dressings will not be possible until the experiments have been continued to a further stage.

Investigations on Magnesium Deficiency in Fruit and Vegetables at Long Ashton.

The results of the fruit investigations obtained to date have been published in three recent papers by the writer in the *Journal of Pomology* (1, 2, 3), and readers are referred to these for details.

The main practical points which have emerged are as follows : -

1. The deficiency has been identified in commercial plantations in several fruit growing areas, including Kent, Essex, Sussex, Surrey, Hants, Somerset, Worcester and Cheshire.

2. The majority of cases have been on apples, but a few on plums, pears, gooseberries and black currants have been noted.

3. The soils of affected areas are usually sands, sands and gravels or light loams.

4. The deficiency appears to be masked in many cases by an initial potash shortage and is not evident until the latter is corrected. Heavy potash manuring may promote magnesium deficiency.

5. The deficiency can be diagnosed in the field by visual methods and the diagnoses can be confirmed by chemical determinations of the magnesia content of leaf samples.

6. More than one season after soil treatment with magnesium-containing materials appears necessary for affected fruit plants to show appreciable recovery from the deficiency.

7. In one experiment annual treatments with stable manure have provided a control of the deficiency for gooseberries and black currants but not for apples.

Observations on magnesium deficiency of vegetables have only been carried out over one season, 1940, and have been confined to one well-defined case on the Research Station farm at Long Ashton.

The soil is a sandy loam, the parent materials of which are composed mainly of colluvial Millstone Grit, with a slight admixture of Trias material.

The area was ploughed up from old grass in 1927, since when it has been cropped continuously with nursery stock, potatoes and miscellaneous vegetable crops. Manuring has been entirely by means of artificials, such as nitro chalk, superphosphate and sulphate of potash, and crops have been excellent.

In the spring of 1940, a portion of the area was planted with summer cauliflowers and later sections with early broccoli, Brussels sprouts and early savoy. All crops made good growth in the early stages, but after a very heavy rainfall in July (7.92 inches for the month) symptoms of magnesium deficiency developed rapidly in the cauliflowers and broccoli, the leaves of the whole of the former crop becoming highly coloured with yellow and white mottling and diffused red and purple tints. Broccoli

were less affected than cauliflowers, and sprouts showed less colouring than broccoli, but there were well-marked patches of poor growth associated with the symptoms on the sprouts.

The savoys appeared practically immune from the trouble, only occasional leaves showing chlorotic mottling. The observations indicated that the cauliflowers were outstandingly susceptible to the trouble, probably due to the rapid rate of growth of the crop. Coloured photographs were taken depicting the symptoms for the various crops and chemical determinations are in progress to determine the magnesium status of the various plants. Trial plots of vegetables have been established on the area on which the susceptibility of various vegetable crops to the deficiency and the control of the deficiency by fertiliser treatment will be studied.

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THE EFFECT OF SEED DRESSINGS CONTAINING GROWTH-PROMOTING SUBSTANCES ON LETTUCE, TOMATO, SUGAR BEET AND DWARF BEAN.

By H. E. CROXALL and L. OGILVIE.

The effect of dressings containing growth-promoting substances on pea seeds has been described by the authors in previous papers (2, 3). The present paper gives the results of experiments in which the seeds of several crops were treated with these dressings and the plants grown to maturity under commercial conditions.

Experimental.

Materials and Methods.

Lettuces, tomatoes, sugar beets and dwarf beans were included in the experiments. A large scale field trial with peas was also laid down, but this was invalidated through damage caused by birds and moles. The growth-promoting substances used were *a*-naphthalene-acetic acid and a preparation of mixed naphthylidene-acetic acids. These substances were incorporated, at concentrations ranging from 1 to 100,000 p.p.m. by weight of the hormone, in talc, cuprous oxide and zinc oxide respectively. All the concentrations employed in the experiments are shown in Table I and numbers are given to the treatments for reference in subsequent tables. The bases and the concentrations employed in each

TABLE I.
COMPOSITION OF SEED DRESSINGS USED.

No. of Treatment.	Base.	Growth Promoting Substance.	Concentration as (p.p.m. of Base).
1	—	Control (no dressing)	—
2	Talc	None	—
3	"	<i>a</i> -naphthalene-acetic acid	1
4	"	"	5
5	"	"	10
6	"	"	20
7	"	"	100
8	"	"	1,000
9	"	"	10,000
10	"	"	100,000.
11	"	Mixed naphthylidene-acetic acids	10
12	Cuprous oxide	None	—
13	"	<i>a</i> -naphthalene-acetic acid	5
14	"	"	10
15	"	"	20
16	"	Mixed naphthylidene-acetic acids	5
17	"	"	10
18	Zinc oxide	None	—
19	"	<i>a</i> -naphthalene-acetic acid	20
20	"	mixed naphthylidene-acetic acids	20

case were those thought most likely to produce results, as indicated in the literature and by the past experience of the writers. The seeds were dressed by shaking them with the dusts in a glass vessel on a rotary shaker for fifteen minutes.

I. Lettuce.

Experiment A. Seeds of the variety Cheshunt Early Giant were treated with talc alone, talc containing from 5 to 200 p.p.m. of *a*-naphthalene-acetic acid and 10 p.p.m. mixed naphthylidene-acetic acids respectively, and with cuprous oxide alone and cuprous oxide containing 5 to 20 p.p.m. *a*-naphthalene-acetic acid and 5 and 10 parts mixed naphthylidene-acetic acids respectively.

In the case of each treatment 200 seeds were shaken with excess of dust. The excess dust was then screened off and the amount adhering was determined. This was 0.8% by weight for the talc dressings and 1.0% for the cuprous oxide dusts.

The seeds were sown in boxes of sterile soil in the greenhouse on Sept. 12th, 1939. No differences in rate of emergence of the seedlings or in the final percentage emergence were noted with any treatment.

The seedlings were pricked out into boxes on Oct. 2nd and planted out into a warm greenhouse on Oct. 22nd and 23rd. The units for each treatment comprised twenty-four plants. The treatments were in duplicate, arranged in randomised blocks.

There was no difference in the time of maturing of the lettuces from any treatment. The lettuces were cut during the first week in March, 1940, and the weight of lettuces from each plot recorded at the time of cutting. The results are given in Table II as percentages of the mean weight of the control, the actual mean weight of lettuces in the control plot being shown in brackets.

TABLE II.
RELATIVE YIELDS OF LETTUCES.

RELATIVE YIELDS OF LETTICES.													
No. of Treatment ..	1	2	4	5	6	11	12	13	14	15	16	17	
Mean weights as % of control.													
(4.41 lb.) ..	100	108.1	99.3	108.7	89.9	101.6	78.8	90.9	115.4	111.8	93.6	87.5	
General Mean, 99.3	Significant Difference at								5% pt.,	15.75			
Standard Error, 5.05									1% pt.,	22.3			

The only treatment differing significantly from the control is 12 (cuprous oxide), in which the mean weight is less than that of the control. This decrease in weight did not occur in the treatments in which growth-promoting substances were incorporated in the cuprous oxide. The mean weight of lettuces in Treatments 14 (cuprous oxide + 10 p.p.m. *α*-naphthalene-acetic acid) and 15 (cuprous oxide + 20 p.p.m. *α*-naphthalene-acetic acid) are significantly higher at 1% point than those from seed treated with cuprous oxide alone. This indicates that incorporation of this acid in the dressing may have overcome a check caused by the

cuprous oxide alone under the conditions of this experiment. In no other case is there any evidence that the growth-promoting substances had any effect, beneficial or otherwise.

Experiment B. In a second experiment with the same variety of lettuce, zinc oxide treatments were included.

Seeds were dressed as before, 1.0% by weight of the cuprous oxide dusts and 0.6% of the zinc oxide adhering to the seed. The seeds were sown in boxes on Sept. 20th, 1939, and the plants were pricked out in boxes and planted out in the warm greenhouse on Oct. 28th and 29th. Each treatment unit again contained 24 plants and there were three replicates of each in randomized blocks. The lettuces were cut in the second week in March, 1940, and the weights recorded as before. The results are given in Table III.

TABLE III.

RELATIVE YIELDS OF LETTUCES.									
No. of Treatment	..	1	12	13	14	15	18	19	20
Mean Weights as % of Control ..	..	100	94.9	99.6	100.4	96.6	95.4	105.3	98.3
(3.57 lb.)									
General Mean, 98.6				Significant Difference at 5% pt., 29.4					
Standard Error, 9.69									

In this experiment there are no significant differences between any treatments. The reduced weights of the lettuce from cuprous oxide and zinc oxide treated seeds are not significant in this experiment.

Some of the plants raised in Experiment B were planted out in a cold greenhouse on Oct. 28th. The treatments used were the same as in Experiment B except that Treatment 20 was omitted. It was possible to have only two replicas of 14 plants each per treatment. The lettuces were cut in the third week in April, 1940, and the weights recorded. The relative weights are given in Table IV.

TABLE IV.

RELATIVE YIELDS OF LETTUCES.								
No. of Treatment	..	1	12	13	14	15	18	19
Mean Weights as % of Control	..	100	102.5	104.5	108.1	168.1	92.0	94.8
(2.33 lb.)								
General Mean, 101.5			Significant Difference at 5% pt., 10.4					
Standard Error, 3.05								

Experiment C. A further trial with the variety Cheshunt Early Giant was carried out in 1940. Seeds were dressed with talc dusts containing 0 to 10,000 p.p.m. of *a*-naphthalene-acetic acid.

The seedlings from seeds treated with the dressing containing the highest concentration of *a*-naphthalene-acetic acid, 10,000 p.p.m., grew at first rather more slowly than those from the other treatments, but at planting out time no differences could be detected. There were no differences in the time of maturing of the lettuces from any treatments nor were there any obvious differences in the size of the lettuces, but it was not possible to confirm this by weighing.

2. Tomato.

Two varieties, Ailsa Craig and Early Market, were used in this experiment. Batches of 100 seeds were treated with talc and talc plus *a*-naphthalene-acetic acid at concentrations of from 10 to 10,000 p.p.m.

The seeds were treated with an excess of the dusts and the amounts not adhering were sieved off. 2% by weight of the dust adhered to the seeds (*i.e.* 0.071 mgm. of dust per seed).

The seeds were sown in boxes of sterile soil on Jan. 28th, 1940. The seedlings from seeds treated with the dust containing 10,000 p.p.m. *a*-naphthalene-acetic acid emerged somewhat more slowly than the seedlings from the other treatments. The seedlings were transferred to "60" pots on Feb. 18th and planted out in the greenhouse on April 1st-3rd. At the time of planting out, the plants from Treatment 9 (10,000 p.p.m. *a*-naphthalene-acetic acid) had outgrown the initial check and were of the same size as the plants from all other treatments.

The unit for each treatment comprised fourteen plants. The treatments were in triplicate, arranged in randomized blocks. Observations were made on the time of opening of the first flowers of each of the first three trusses. No differences in the time of flowering for any treatment could be detected.

Picking began on June 29th and continued until Sept. 6th, when all fruits of marketable size were removed from the plants. The total weights of fruits picked were recorded. There were no significant differences in the weights from any treatment, as is shown in Table V. Examination of the weights picked during the first month showed that there were no differences in earliness of ripening due to the treatments.

TABLE V.
RELATIVE YIELDS OF TOMATOES.

No. of Treatment	..	..	2	5	7	8	9	
<i>Var. Ailsa Craig.</i>								
Mean Weights as % of								
Control	..	..	..	100	110	98	101	104
(65.6 lb.)								
General Mean, 103				Significant Difference at 5% pt., 57.6				
Standard Error, 17.9								
<i>Var. Early Market.</i>								
Mean Weights as % of								
Control	..	..	..	100	118	105	97	108
(62.2 lb.)								
General Mean, 106				Significant Difference at 5% pt., 22.6				
Standard Error, 6.75								

3. Sugar Beet.

Preliminary experiments in the greenhouse had indicated that the rate of emergence of sugar beet seedlings was not influenced by seed dressings containing growth-promoting substances. There were no differences in the weights of potted plants raised from seeds treated with dressings containing concentrations from 1 to 20 p.p.m. of *a*-naphthalene-acetic acid. But as greenhouse conditions are entirely different from those in the field a small field trial was laid down.

Seed of the variety Desprez Elite was treated with each of the dressings at the rate of 0.5% by weight of the seed. The seeds were sown on April 25th-27th in drills 1 ft. 6 ins. apart, at the rate of 20 lb. per acre. There were four replicates of each treatment in randomized blocks, each plot being 22 ft. by 6 ft. No differences in time of emergence of the seedlings from any treatment were observed.

The plants were gapped and singled at the four-leaf stage to leave 10-11 ins. between plants. The plots were hoed and kept clean according to the usual commercial practice. The beets were lifted and topped during the first week in October. The roots from each plot were washed and weighed. The mean yields per plot are given in Table VI.

TABLE VI.
RELATIVE YIELDS OF SUGAR BEET.

No. of Treatment	2	5	7	8	9	10
Mean Weights as % of Control	100	89.6	89	95.1	88	102
General Mean, 94	Significant Difference at 5% pt., 35.8					
Standard Error, 11.9						

The incorporation of growth-promoting substances in the seed dressings did not influence significantly the yield of sugar beet under the conditions of this experiment.

4. Dwarf Bean.

Seeds of dwarf bean, variety The Prince, were treated at the rate of 0.25% by weight of the seed with talc and talc plus *a*-naphthalene-acetic acid at 1 to 100 p.p.m.

The seeds were sown on May 2nd, 9 ins. apart, with 2 ft. between rows, in plots 10 ft. square. There were four replicates of each treatment in randomized blocks.

The beans were picked on July 22nd and Aug. 7th and the crop weights recorded. The relative yields per plot for the two pickings are given in Table VII.

TABLE VII.
RELATIVE YIELDS OF DWARF BEAN.

No. of Treatment	2	3	5	7
Mean Weights as % of Control (14.44 lb.)	100	99.4	101.5	98.9
General Mean, 100	Significant Difference at 5% pt., 86			
Standard Error, 26.2				

Under the conditions of this experiment treatment of the seeds with dusts containing growth-promoting substances had no effect upon the yield of beans.

Discussion.

Seeds of lettuce, tomato, sugar beet and dwarf bean were treated with dressings containing growth-promoting substances. When talc was used as a base for the dust, in no case did any concentration of growth-promoting substances influence the crop yield significantly.

In the lettuce experiments the growth-promoting substances were incorporated in cuprous oxide and zinc oxide in addition to talc. In one experiment seeds treated with cuprous oxide alone produced lettuces which were significantly less in weight than those from untreated seeds. The lettuce from seeds treated with cuprous oxide plus growth substances did not show this diminution in yield. This indicates that a check to growth caused by the cuprous oxide may have been overcome by the incorporation of *a*-naphthalene-acetic acid in the dressing. Too much emphasis, however, cannot be placed on this result since lettuce grown in both warm and cool houses from a second sowing of the same variety did not show this decrease in weight as compared with controls.

Apart from this one result the growth-promoting substances had no influence on the crop weights of the varieties used under the conditions of these experiments. These results are in agreement with those obtained by Templeman and others (1, 5, 6), but, as pointed out by Hopkins (4), external conditions, especially soil moisture, may influence the effect of growth-promoting substances on seeds.

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LETTUCE GROWING IN THE BRISTOL PROVINCE.

By L. OGILVIE.

As a readily available source of vitamins A and B, lettuce is of great value in war-time. It is an easily grown crop which, under suitable methods of cultivation, can be matured at practically any time in the year.

The specialised production of this crop has been largely neglected in the Bristol Province, except by a few enthusiasts, who, it may be mentioned, have owed much to the previous experience and experimentation of F. A. Secrett and W. F. Bewley (12, 13). The area appears to be well suited to the cultivation of lettuce, on account of its relatively mild winters and plentiful sunshine. Now that practically every glass-houseman is raising lettuce the following notes, compiled during a study of lettuce diseases and of the classification of lettuce varieties, may be of value.

It should be realised at the outset that in order to obtain marketable lettuces in any particular month it is necessary to choose a suitable variety and to grow the plants in the open ground in an exposed or sheltered locality or to employ frames, cloches, hot beds, cold or heated houses, etc., according to the time of year.

Old and New Varieties.

The history of lettuce growing has been marked by a continuous change of varieties.

In the 19th century and up to 1914 cos varieties were more widely grown than cabbage lettuce varieties. This is probably because the cabbage varieties then available were comparatively coarse. The cos varieties were at that time preferred for salads, while the cabbage varieties were used more for soups. Even at a later date cabbage varieties made less on the market than cos varieties, but the position is now reversed. The Ministry of Agriculture set its seal of approval on cabbage lettuce by instituting grading regulations for the crop under the National Mark Scheme (3).

Since the early part of the 19th century up to the present day new varieties have been continually introduced, and over 200 English varieties are now available. These varieties are not by any means distinct. Some are synonymous while all can be grouped into some eight classes (7).

The optimum type of lettuce required for the market has now been tablished by the Ministry's "Grade Designations and Statutory

Definitions for Cabbage Lettuces under the National Mark Scheme" (3). 'Each lettuce, when encompassed by hand and reasonably compressed, shall measure not less than $3\frac{1}{2}$ ins. in diameter in the case of "Selected Hearted"—3 ins. in diameter in the case of "Selected Hearted Glass-house." The lettuce in any one package shall be reasonably uniform in size and shall not vary in diameter by more than 1 in.'

The older varieties were often coloured or had coloured spots, their shapes were not uniform, they were too large or too small for market purposes, they hearted poorly or the leaves were excessively tough. It may be noted here that although the popular demand is for a lettuce with a crisp and blanched heart, "the blanched inner leaves contain only 420 int. units of vitamin A per ounce, whereas the outer green leaves contain 1400 int. units (11)."

Again, many of the varieties which have been introduced from time to time have proved unsuitable on account of lack of hardiness or unsuitability for forcing, while others have been discarded because of their susceptibility to certain diseases.

Lettuces in the Open Ground.

The practice of sowing lettuces late in August or early in September to stand the winter is fully described in gardening journals of the early 19th century. This method was largely used in the Evesham district prior to 1914 (8), "seeds of cabbage (lettuce) varieties were sown in August and produced plants for setting under plum trees and cutting in April and May."

The seeds are sown in rows or broadcast and the young plants are set out in their permanent quarters some 6 ins. apart after four or five weeks and even right into November. Throughout the winter growth is practically at a standstill, but in late February and March growth recommences, the plants maturing in early May.

It is important not to have the plants so far forward in the autumn that they become severely injured by frosts. On the other hand if the small seedlings are set out at a late date they are liable to be lifted out of the ground by frosts, especially if the soil is insufficiently consolidated. It is better in such circumstances to leave the plants in the seed-bed and to transplant during suitable weather in February.

In market gardens around Bristol and Cheltenham and in the Evesham area such varieties as Bristol Cos, Bath Cos, Hardy Hammersmith, Lees Immense, MacHattie's Giant and Stanstead Park were formerly grown, but all these suffered from one or other of the faults described above and are now being replaced by "Passion" varieties (7) such as Arctic, Arctic King, Imperial, Winter Crop, Winter White, Winter Victor, etc. Imperial now appears to be the most commonly grown winter-hardy variety. There was a severe test of its hardiness during the exceptional winter of 1939-40. Around Cheltenham many 100% stands of this variety could be observed in the spring.

Some growers have attempted to grow lettuces of the May Queen and Trocadero groups as hardy winter lettuces, but except in the mildest winters their survival has been very unsatisfactory.

Trials carried out at the Worcestershire (C.C. Experiment Station, Perdiswell, from 1935 to 1937 (9) indicated that though many of the Passion group survive the winter successfully they are liable to be killed off in a wholesale manner by *Botrytis* in early spring. In the trials in question the average survival rate of 18 Passion varieties was 48 per cent. Stanstead Park is more resistant to *Botrytis* than some of the newer varieties, but is unsatisfactory in hearting, colour and toughness. Arctic and Arctic King are probably more resistant than Imperial but are slightly smaller. In the control of *Botrytis* it is important to see that the ground is well drained and adequately supplied with potash.

Imperial is often badly infected with Ring Spot, caused by *Marssonina panattoniana*, especially where the same ground is used for lettuces year after year, as at Cheltenham. Where epidemics are less severe there is also some indication of seed infection, as has been suggested by Stevenson (15). A prominent grower in the Evesham district says he avoids this disease entirely on ground where the disease was formerly troublesome on winter hardy lettuces by growing seedlings of the Trocadero group under glass and planting out in early spring, a method described below. This is possibly because by leaving the ground fallow he allows time for the fungus to disappear from debris in the soil.

Total loss of crop may result from mosaic infection following heavy aphid infestation in the late summer (6). Here again infection can be largely avoided by sowing in houses or frames and transplanting to the open ground. Some of the older varieties, such as MacHattie's Giant, are so badly affected that they form no heart, and this may be an additional reason for their disappearance from general cultivation. Stanstead Park is little affected and Imperial moderately so.

Other Ways of Managing Winter Lettuces.

In the neighbourhood of Bristol winter-hardy varieties of lettuces may be sown in frames from October to December, pricked out in frames, and transplanted to the open ground from February onwards. Varieties which have responded well to such treatment are Imperial and Arctic.

In the Cheddar district if Imperial is sown in late August it can be matured by Christmas under cloches if there is a fair amount of sunshine. Without cloches it will mature in sheltered spots by early March. Winter hardy varieties are also brought on early in the Bristol district by the use of cloches. The variety Spring Beauty is suitable in this respect.

Spring Lettuces.

Winter-hardy lettuces, as an entirely outdoor crop, appear to be unsuccessful in the Eastern Counties and instead varieties of the Trocadero group, which are pre-eminently summer lettuces, are sown in frames from October to November, pricked out, and planted out in the open

ground in February, March or April. In the hands of several keen growers this method has given excellent results in the West. The best Trocadero varieties, such as Improved Unrivalled, Borough Wonder and Market Favourite, which are practically free from objectionable colour, are sown in boxes in a cool greenhouse late in October or early in November, or in a warm greenhouse in December to mid-January, according to locality, pricked out when quite small in boxes, hardened off gradually and planted out in the open in late February. The plants heart up during May. Several growers get their crop slightly later by sowing Trocadero varieties in heated houses early in January, pricking out into boxes in early February and finally planting out in mid-March.

Varieties of the May Queen group (May Queen, May King, May Duke, Queen of the May, Earliest Springtide, Victor Forcing, Winter Victor, etc.) may also be grown successfully in the spring. These are rather large lettuces with delicate leaves. They heart well, but have large spreading lower leaves which keep the soil moist and lead to *Botrytis* attack. They usually have a tinge of brown or purplish colour which becomes more marked when the plants are growing slowly and in cold weather.

May King can be treated in exactly the same way as the Trocadero varieties described above and will heart up slightly earlier than these. Both these groups are grown successfully in this manner near Bath. A prominent Wiltshire grower sows May King in frames and plants out in the open early in March. The plants heart up better and are slightly earlier and softer than Imperial treated in the same way. Feltham King and Spring Beauty (All the Year Round varieties) have also done well when planted out from frames in February.

All these lettuces can also be sown in the open ground when danger from frost is over.

Summer Lettuces.

Summer lettuces are comparatively little grown in the Province. At Evesham varieties of the Trocadero group are favoured and this group is usually considered to be the outstanding one for summer cultivation owing to its excellent hearting, uniformity and resistance to drought. The Trocadero group is easily recognised by the inward folding of the leaves of the young plants, and in the mature plants by the peculiar S bend of the outer leaves.

Although generally not greatly favoured for market purposes the Crisp varieties are remarkable for their crisp and delicately flavoured hearts which probably constitute the best summer salad vegetable. In variety trials carried out at Long Ashton the French variety Chou de Naples was first in hearting and crispness with the well-known Webb's Wonderful not far behind. Summer Standwell was also good. The crisp varieties are less liable to run up into flower in warm dry weather than any of the other groups.

It may be noted that the Trocadero and Crisp groups constitute the bulk of the lettuce grown in the United States, the chief American varieties being Big Boston and New York respectively.

All the Year Round or Butterhead varieties also do well in the summer. These constitute the bulk of the many varieties offered by seedsmen and vary in size from very small to very large plants. Some, especially the French varieties, are tinted with shades of purple and could be used to make decorative salads.

Summer lettuces drilled and transplanted in the open can usually be depended upon to produce a good stand. For a very late crop to be marketed from October onwards till severe frosts it is suggested that sowings be made about the first week in August and the plants thinned out.

Mosaic disease is usually of little importance on summer lettuces because the aphides which carry the disease are usually by that time parasitised and lessened in numbers. There is sometimes a little loss from Sclerotinia Disease, known as Drop in the U.S.A., and caused by the fungus *Sclerotinia Sclerotiorum*. This attacks plants here and there in the fields, causing them to wilt. Affected plants should be dug up, with some of the surrounding soil, and burned, to prevent soil infestation.

Lettuces in Frames and Dutch Lights.

Several growers in the Province specialise in the culture of lettuces in frames or Dutch lights, thus producing more tender plants than those resulting from purely open-air cultivation. The variety usually employed is the black-seeded Gotte à forcer. This is sown in cool houses or frames from August onwards and planted out in hot beds or Dutch lights. The frames or lights receive no ventilation and are covered with matting during frosty weather. The new selection of Cheshunt Early Giant, Cheshunt Early Ball, does well under similar treatment.

Similarly the May Queen varieties and Feltham King (an All the Year Round variety) do well in frames and Dutch lights in the spring. Ventilation should be given to these varieties during all periods of fine weather. Sown in mid-October and pricked out and set out in frames from the first week in February, these varieties should mature about April.

Lettuces in Cool Houses.

Cheshunt Early Ball does well in unheated greenhouses during the winter. Thus at Long Ashton this variety was sown early in September, planted out on September 30th and was ready for market early in February. Other sowings were made for succession. Both this variety and Cheshunt Early Giant are rather prone to Downy Mildew (*Bremia Lactucae*) and every effort should be made to check drips from the roof and waterlogging of the soil. The occurrence of this disease has been so widespread this winter, even in houses which have not grown lettuces before, as to suggest seed infection.

Cheshunt Early Ball, with its upright habit of growth, appears to be less affected by *Botrytis* than Cheshunt Early Giant, which goes down with *Botrytis* badly in cool houses. The writer, however, has seen excellent crops of Cheshunt Early Giant grown in Somerset in cool houses watered well to start with and kept fairly dry. One, for instance, composed of Dutch lights, was planted up in mid-November and was ready for cutting in mid-February. Another in a coastal district, sown in place in the end of November and thinned out, was cut from early February onwards. Both Cheshunt varieties will stand several degrees of frost.

The variety Early French Frame, especially the Blackpool selection which is somewhat resistant, but not entirely, to Downy Mildew, is also useful for cool houses throughout the winter.

For slightly later maturing in cool houses May King is used extensively. Thus in Gloucestershire, where this variety is grown on a large scale, it is planted out in cool houses during the second week in November and matures in March. Slight heat is sometimes put on while the plants mature to induce earlier ripening. Before they are planted out in the houses the soil has a basal dressing of steamed bone flour or other phosphate and potash, and the lettuces are followed by tomatoes which do not require further fertilisers.

Great care should be taken in watering lettuces in cool houses. The soil should be flooded prior to planting out and no more watering should be given till it is absolutely necessary. Hoeing will help to conserve moisture. Watering may be required about once a week towards the end of the growing period and then it should be applied by means of a hose, with a $\frac{1}{2}$ in. pipe fitted in the end, which is directed between the plants.

Lettuces in Heated Houses.

Cheshunt Early Giant is usually the most satisfactorily variety for heated houses. It is deep green, tender and hearts well during the short winter days. At Long Ashton, for instance, it was sown in the greenhouse in mid-September, pricked out into boxes after about ten days, planted out in a tomato house on October 4th. and matured before Christmas. This variety grows so quickly that a succession of three crops may be had during the winter, the later sowings being made in the beginning of October and January and the plants being fit to cut in mid-February and mid-March. As the variety is a short day lettuce it should not be sown earlier than mid-August or later than the beginning of January. The earliest sowings are sometimes made out of doors, but this practice often leads to severe aphid damage and mosaic infection in the houses.

Next to Cheshunt Early Giant, Golden Ball, the Blackpool strain of Early French Frame and Gotte à forcer are some of the best varieties.

In the cultivation of Cheshunt Early Giant it is most important, in order to avoid wholesale loss due to *Botrytis*, to maintain an even

temperature of about 50°F. It should not exceed 55°F for any length of time, nor fall much below 50°F, otherwise condensation of water in the plants will result, with disastrous results. The plants should be kept rather dry and water should be given only when the plants require it and in the manner described above. If the plants are grown on small ridges they are less liable to severe injury from *Botrytis*, but hearting up may be slightly later. The air should be kept buoyant by ventilation wherever possible. A workman should go round the houses every morning with a bucket in which should be put any leaves showing *Botrytis* infection, or diseased plants.

May Queen varieties, such as First of All, Dutch Early Yellow, Delice, Reine de Mai, etc., were formerly used for forcing, but their susceptibility to *Botrytis* renders them unsuitable.

An unusual method of cultivation found in two greenhouses may be mentioned here. Tom Thumb or Commodore Nutt lettuces (a very small All the Year Round variety) were pricked out in heated houses into boxes where they were allowed to mature. The boxes of small plants were then sold in department stores.

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A REPORT ON SIX 10-ROD DEMONSTRATION ALLOTMENTS IN THE BRISTOL DISTRICT IN 1940.

By E. W. HOBBS.

The present account records the cropping results and experience obtained in 1940 on a number of Demonstration War-time Allotments in the Bristol District, established and worked under the direct guidance of the writer.

The plots were cropped, with slight modifications, as recommended in Growmore Leaflet No. 1*, First Edition, Oct. 1939, of the Ministry of Agriculture and Fisheries, to which reference should be made for details of layout, cropping, quantities of seed, sowing dates, etc.

The plots in the City of Bristol were established at the request of the City Council Small-Holdings and Allotments Horticultural Sub-Committee, on which the writer served as technical adviser.

The Plots.

Locations. Six plots, each of 10 square rods, were included in the scheme, three at the Research Station, Long Ashton, and three in the City of Bristol: situated at Horfield Common; Chapel Lane, St. Georges; and at St. Anne's Park, Brislington.

The layout of the plots at the Research Station and the scattered location of the three Bristol plots provided sufficient variation in conditions for the data to reflect with reasonable accuracy the crop yields possible from a standard 10-rod allotment under average conditions in the District.

Sites and Soils.

Research Station. The plots are on a medium loam of medium depth, derived from Keuper Marl, and with fairly good drainage. The lime content of the soil was adequate and available phosphate and potash were both medium. The land, previously arable, was heavily infested with couch grass when taken over.

Horfield. The site was an old grazing meadow prior to 1940, and the soil is a heavy calcareous clay derived from the Lower Lias. The soil is shallow to medium in depth and overlies Lias Limestone rock; drainage is slow. The lime content is naturally high, whilst available phosphate was extremely low and available potash low.

* Growmore Bulletin No. 1 was revised in February 1941 and the cropping plan has been slightly altered in the light of experience gained with the original plan.

Chapel Lane. The plot was partly on an old house garden site (freed by a slum clearance scheme) and partly on derelict market garden land. The original soil was derived from Coal Measures Clay, but the top-spit is now largely made up of cinders and rubble and overlies a heavy, yellow clay. Drainage of the surface soil is good. The lime content, available phosphate and available potash were all high.

St. Anne's Park. This is an old allotment ground, having been cropped continuously from 1909 to 1937 when the area was roughly levelled preparatory to laying out a park. The land reverted to allotments in the Spring of 1940. The soil is light and sandy and is derived from Pennant Sandstone. Drainage is good and the lime content was adequate for vegetable culture. Available phosphate was medium to high and available potash was moderate.

Management.

All six allotments were under the supervision and general direction of the writer, who also carried out the main work on the Research Station plots. The three Bristol plots were each worked by a newcomer to vegetable gardening, so that these plots started with no special advantage of experience and skill on the part of the plot-holder.

Preparation of the Sites.

The digging of the Research Station plots was completed in February, but none of the Bristol plots were dug until the first week in April.

Such a late start left no time for other than single spit digging and the soil had to be broken down as digging proceeded in order to aid consolidation before seed sowing which followed a few days later.

The turf at Horfield was almost free of perennial weed and was dug in. The other two plots were in a very dirty condition, being over-run with perennial weeds such as Couch Grass (*Agropyrum repens*), Creeping Thistle (*Carduus arveniss*), Dock (*Rumex obtusifolius*), Bindweed (*Convolvulus sepium*).

The Chapel Lane plot was littered with old tins, broken glass, etc., and much sorting out had to be done as digging proceeded. A sharp bank had also to be levelled out.

Manuring.

Each plot (10 rods) received the following fertilisers, broadcast over the digging before preparing seed beds: 20 lb. sulphate of potash and 30 lb. superphosphate. Nitrogen was applied only as top dressings to growing crops later in the season and each plot received in this manner about 20 lb. of sulphate of ammonia.

Arrangement of Crops.

An area of 10 square yards was set aside on each allotment as a seed bed for the raising of plants such as sprouts, cabbage, leeks, lettuce,

etc. The remainder of each allotment was divided into three equal portions A, B, and C, and the crops grown were grouped in order to allow of a simple rotation in the future, *e.g.* A, B, C ; C, A, B ; B, C, A.

Section A, comprised Carrots, Parsnips, Swedes and Potatoes.

Section B, comprised Autumn and Winter Cabbage, Brussels Sprouts, Sprouting Broccoli and Scotch Curled Kale.

Section C, comprised Peas (followed by Leeks), Onions (followed by Spring Cabbage), Broad Beans, Dwarf and Haricot Beans and Runner Beans.

Except for the impossibility of being able to make early sowings of broad beans, parsnips and onions on the Bristol plots, owing to the late date of the first digging, all other crops on the six plots were sown or planted out within the course of any one week.

Seeds were sown thinly and in the case of beetroot and parsnip they were sown in spaced groups.

Early carrots lifted in June were followed by swedes. Thus two root crops followed one another during the year and yields of both were good.

Composting.

To ensure at least some small supply of organic matter for the future, a compost heap was established on each plot. On to this heap went all vegetable refuse and surplus leafy matter grown on the plot. This material comprised potato haulms (except eelworm-infested plants at St Annes), leaves and stalks (previously bruised) of brassicas, pea and bean pods, root tops, annual weeds, etc. The heaps were occasionally sprinkled with a little nitro-chalk and were thoroughly turned in the early winter. It was found that sufficient material accumulated from early summer until mid-December to enable a fair coating of well-rotted compost to be applied over 50 square yards of ground. An accumulation over a full twelve months therefore should provide a dressing for about one-third the area of a 10-rod allotment plot.

Pests and Diseases.

Black Aphis (*Aphis fabae*) appeared on all bean crops, but was kept under reasonable control by continuous dustings with Derris powder.

Cabbage Aphis (*Brevicoryne brassicae*) affected all the brassicas, as also did caterpillars of the Cabbage Butterflies. Frequent dustings with Derris powder provided an effective control.

Cabbage Root Maggot (*Phorbia brassicae*) was serious on surrounding plots in the Chapel Lane and St. Anne's area, but the use of calomel dust at the time of planting and once again about 10 days later on the Demonstration Plots warded off any serious attack.

No attack of Carrot Root Fly (*Psila rosae*) was noticed at any centre.

The most serious disease met with was Potato Eelworm at St. Anne's Park. This land had been allotments almost continuously since 1909, and potato eelworm infection is general throughout the whole field.



Onion Crop at Long Ashton on Allotment No. 2.

Weight of harvested bulbs 101 lb. from 240 feet total length of row

Special Observations on each Centre.

Research Station. The ill-effects of summer drought were largely countered by constant hoeing which at the same time reduced a heavy weed infestation. No cultural problem of note was encountered.

For the purposes of demonstration the three Research Station plots were located side by side, thus occupying an area of approximately 30 yds. by 30 yds. Plot 1 followed the first year's arrangement of crops, i.e. A, B, C; Plot 2 showed the second year rotation as C, A, B; and Plot 3 showed the third year's rotation as B, C, A, thus :—

1st year.	2nd year.	3rd year.
A	C	B
B	A	C
C	B	A
Plot 1	Plot 2	Plot 3

This simple arrangement, in addition to randomizing the crops, demonstrated the rotation scheme on each plot and also across the three parallel plots and proved a valuable help in explaining the scheme to visitors.

Horfield. Seedling development was slow and the early summer drought further retarded growth. Onions (both from seed and set out as plants) failed altogether, as did sowings of turnip and swede, and seedlings from successional sowings of round-leaved spinach failed to develop beyond the second leaf stage. As opposed to this it is worth recording that both carrots and parsnips were highly successful, the parsnips turning out particularly well. Potatoes also yielded a good crop.

As the season advanced the older leaves of brassicas showed marked symptoms of phosphate deficiency. The failure of the turnips, swedes and onions is typical of soils deficient in phosphate, as also was the slow recovery of brassicas crops after planting out, due to extremely poor root formation.

When planting out spring cabbage in September, the dibber holes were filled with a prepared compost with a small addition of superphosphate, and it is interesting to note that the young plants made new roots and established themselves noticeably more quickly than the brassicas planted out earlier in the year.

Chapel Lane. The soil is light and amply supplied with organic matter. Seedling development and the recovery of transplanted plants was rapid.

In early mid-summer, however, it was noticed that beetroot leaves became peculiarly mottled with yellow and brown patches; the plants failed to develop further leaf from the centre of the crown and the roots ceased to grow. Round-leaved spinach failed in a like manner and failed to grow beyond the first true leaf stage.

Further observations showed peas and potatoes to be carrying peculiar symptoms, although in these cases crop yields seemed little affected.

The trouble was diagnosed as manganese deficiency, a condition resulting from generations of cropping coupled with the practice of frequent applications of dung and lime. Crop failures or poor yields of beetroot in particular were found to be general throughout the area from this cause.

St. Annes. The supply of organic matter on this plot was low, and after rains the soil quickly "ran together" and became compacted in the manner typical of humus-deficient soils.

This condition made it advisable to work seed beds down to no finer than a coarse tilth, and in this way seedling development was not retarded by reason of the development of a crust-like surface. Constant hoeing and stirring of the soil was necessary to keep an open tilth and to prevent the appearance of numerous surface cracks.

Crop Results.

A record was kept of all crops harvested from each of the six allotments, and the figures in the accompanying table refer to crops harvested from early Summer to mid-December.

In addition to the tabulated crops a plentiful supply of parsley was maintained throughout the year and a small quantity of runner and dwarf bean seed was saved from the Research Station plots.

All plots were well supplied with winter greens which should provide a succession until the following May.

Crops unharvested in December included a further picking of Brussels Sprouts, plus the "tops"; Christmas Cabbage; a few Savoys; Purple Sprouting Broccoli; Scotch Curled Kale; Spinach Beet; Leeks (approx. 150 plants per plot); Turnips for greens; Parsley; a bed of Spring Cabbage. These crops should provide sufficient quantity and a succession to maintain a supply of fresh green vegetables until spring-sown crops come into production.

General Discussion.

The digging in of the turf on the Horfield plot produced a marked improvement in the soil texture at the end of the first season. The turning in of turf at so late a date would not generally be considered good practice but no bad effects, *e.g.* hollow or spongy seed beds, resulted from this procedure.

Unfortunately, most plot holders in the field insisted on burning the turf with the erroneous idea of obtaining "heaps" of potash.

Frequent observations of allotment gardens situated in the three areas around which demonstration plots were established revealed a measure of success or failure on an area basis which can only be attributed to particular soil factors, which in great measure over-rode almost completely the skill or otherwise of the cultivators.

Thus at Horfield development of most crops was extremely poor, transplanted plants in particular recovering very slowly.

At Chapel Lane seedling development was rapid and transplanted brassicas recovered quickly in spite of dry weather.

At St. Annes the general impression obtained when looking over the allotment area was a pleasing one. Crops generally grew rapidly, recovery of transplanted plants was rapid and leaf development was very good. The only exception was the potato crop, which was either poor or a failure over the whole area owing to eelworm attack.

In September these differences evened themselves out in large degree on the demonstration plots, probably due to the action of fertilizers and to thorough attention to cultivations, and the crops on these plots stood out generally from neighbouring ones as being much better developed. This was notably the case with brassica crops at Horfield.

The main impression over the areas in question, however, held true until the winter. It would seem, therefore, that although local soil conditions do influence success or failure to a marked degree, attention to cultural requirements as indicated by soil conditions and fertility level, observation of plant development and careful soil management can in large measure overcome initial problems and ensure satisfactory results.

Practical Conclusions.

Observations based on the experience gained in one season's management and cropping of standard 10-rod allotment plots point to the following conclusions:—

(1) A newcomer to vegetable gardening can undertake the cultivation of a 10-rod allotment and achieve a fair measure of success, provided the proper technical and practical advice is afforded him.

(2) The breaking up of old grazing land may not necessarily render manuring unnecessary for a year or so. This point was well demonstrated at Horfield, where the fertility level was distinctly poor and the initial application of 30 lb. superphosphate and 20 lb. sulphate of potash could have been increased to advantage.

(3) The preservation and digging in of turf has a noticeable and beneficial influence on tilth. Extra precautions are necessary, however, to ensure sufficient consolidation when digging is done late.

(4) Under conditions in the Bristol District sufficient vegetable waste can be composted over the period of a year to dress one-third of a standard allotment. Failing any other source of organic matter, therefore, Sections A, B, and C could be dressed once every three years.

(5) The amounts of seed required are extremely small and the quantities recommended in the Growmore Leaflet No. 1 (first edition) are ample, even with unskilled sowing. With a modicum of skill in ensuring even and thin sowing an appreciable saving can be achieved.

(6) The arrangement of crops as set out in the Growmore Leaflet rotation is easy to follow, and provides a well-balanced scheme of cropping. The all-important roots for winter storage and greenstuffs for winter use are given due prominence, and the area allotted to summer vegetables is ample without encouraging "glut" production.

(7) Vegetables obtainable from a 10-rod allotment can provide a succession over a whole twelve months. Provided potatoes are kept down to about one-sixth of the area sufficient other vegetables can be grown on the remainder to supply the normal needs of a family of three or four throughout the year.

Acknowledgments.

Thanks are due from the writer to the following :—To Mr. J. E. Beviss for voluntary help in cultivating the Research Station plots, and to Messrs. C. H. Gibbons, Horfield; R. Bowditch, Chapel Lane; and F. R. Davis, St. Annes, for undertaking the cultivations and recording on their respective plots.

DEMONSTRATION ALLOTMENTS, SEASON 1940.—CROPPING TABLE.

CROP YIELDS IN LB. FROM EACH OF SIX PLOTS, CROPPED (MAINLY) AS RECOMMENDED IN GROWMORE LEAFLET NO. 1. RECORDS TAKEN FROM SPRING UP TO MID-DECEMBER.

Crop.	Varieties.	LONG ASHTON GROUP.			BRISTOL GROUP.		
		Allotment 1.	Allotment 2.	Allotment 3.	Horfield.	Chapel Lane.	St. Annes.
Beans, Broad	Johnson's Longpod	10	11	13	7	21	18
" Dwarf	Masterpiece ; Black Prince	19	27	25	30	15	10
" Runner	Best of All	46	44	49	31	28	60
Beetroot	Crimson Globe ; Cheltenham Greentop	56	61	61	6	12	35
Broccoli, Sprouting	Purple Sprouting	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.
Brussels Sprouts	Favourite	30	38	43	30	18	36
" Tops	—	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.
Cabbage, Spring	Ellam's Early ; Flower of Spring	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.
" Summer	Ironside	42	57	45	30	23	73
" Autumn	Winningstadt	53	52	30	30	Not cut.	Not cut.
" Christmas	Christmas Drumhead	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.	Not cut.
Carrots, Early	Early Model	42	40	48	70	30	41
" Maincrop	Scarlet Intermediate	117	133	131	24	15	27
Cauliflower	Majestic	Not grown.	Not grown.	Not grown.	Not cut.	Not cut.	Not cut.
Kale	Dwarf Scotch Curled	Not cut.	Not cut.	Not cut.	Not lifted.	Not lifted.	Not lifted.
Leeks	Musselburgh	Not lifted.	Not lifted.	Not lifted.	16	15	20
Lettuce	All the Year Round	19½	23	21	50	42	55
Marrows	White Trailing	45	48	60	Total failure.	18	14
Onions, Spring	Bedfordshire Champion	6	3	8	Total failure.	94	100
" Bulbs	"	123	101	129	148	24	40
Parsnips	Student	161	212	165	8	22	26
Peas	Onward ; Duplex ; Kelvedon Wonder	14	16	22	344	310	92*
Potatoes	Sharps Express ; Majestic	378	482	420	120	29	120
Savoys	Late Green	75	94	99	Not grown.	Not grown.	Not grown.
Shallots	Giant	11	11½	10	12	12	7
Spinach Beet	Spinach Beet	28	28	28	Failure.	14	50
Swedes	Garden	103	87	83	Failure.	16	50
Turnips, Roots	Early Milan	38	40	57	Failure.	Not cut.	Not cut.
" Tops	Winter White	Not cut.	Not cut.	Not cut.	24	15	13
Tomatoes	Market King	16	16	15	950	773	928
TOTALS		1426	1622½	1668½	* Fieldworm attack.		

THE PREVALENCE AND SIGNIFICANCE OF PEA SEED INFECTION BY *ASCOCHYTA* SP.

By C. J. HICKMAN, M.Sc.

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Introduction.

An investigation was begun in the spring of 1940 to obtain information on the incidence and significance of infection of commercial stocks of pea seed used in this country by the three fungi *Ascochyta Pisi*, *Mycosphaerella pinodes* and *Ascochyta pinodella* (1). While the results of this investigation reported here are interesting, any conclusions which may be drawn must be regarded as tentative, for they are based on the results of one season's work only.

Laboratory and Greenhouse Investigations.

Observations were first made on the degree of infection present in commercial seed samples, which were obtained through the courtesy of several of the larger seed firms in this country. Wherever possible, several stocks of a variety, grown in this country and abroad, were examined, to discover whether any connection existed between the amount of infection and the source of the seed. One hundred seeds of each sample were placed on damp filter paper in petri dishes and counts were made, usually after three days, of the seeds showing the characteristic, fluffy *Ascochyta* mycelium. Where there was any doubt as to the identity of the fungus present, a microscopical examination was made. Where the percentage infection exceeded ten, single spore isolations were made from ten infected seeds selected at random; where it was less than ten, isolations were made from every infected seed. The cultures thus obtained were identified by reference to type cultures and to published descriptions. Germination tests were also made in moist sand, using samples of fifty seeds.

Table I shows the percentage infection by *Ascochyta* sp. (A), and the percentage germination in moist sand (G), of the samples examined.

It will be observed that in those varieties where stocks from different sources were examined, the percentage infection was considerably higher amongst those grown in England. Apart from isolated cases the incidence of infection was very low amongst the stocks raised abroad. In some of the countries the reason for this is probably to be found in the climate. In Hungary and Morocco, for example, where the climate is continental in type, the hot, dry summer will be most unfavourable towards the development of *Ascochyta* and most favourable towards quick ripening of the seed. Such a relation between climate and seed infection was found by Jones (1) in the United States of America. Seed produced in

TABLE I.

PERCENTAGE INFECTION BY *Ascochyta* (A) AND PERCENTAGE GERMINATION (G) OF SAMPLES OF PEA SEED FROM VARIOUS SOURCES.

Variety.	England.		Hungary.		Morocco.		New Zealand.		Holland.	
	A	G	A	G	A	G	A	G	A	G
Foremost (1) ..	48	64	16	86	—	—	—	—	—	—
Foremost (2) ..	36	60	5	88	—	—	—	—	—	—
Foremost (3) ..	9	100	—	—	—	—	—	—	18	74
Foremost (4) ..	42	62	12	82	—	—	—	—	—	—
Lincoln (1) ..	4	90	0	98	0	92	0	98	—	—
Lincoln (2) ..	3	82	—	—	0	96	0	84	—	—
Thomas Laxton (1)	43	74	3	94	—	—	—	—	—	—
Thomas Laxton (2)	—	—	0	100	0	96	—	—	—	—
Thomas Laxton (3)	1	92	—	—	—	—	—	—	3	90
Onward (1) ..	47	80	—	—	1	86	—	—	—	—
Onward (2) ..	15	88	0	88	—	—	0	90	—	—
Onward (3) ..	10	84	0	88	—	—	—	—	3	88
Onward (4) ..	8	84	0	88	—	—	0	90	—	—
Gradus ..	34	70	1	86	—	—	0	94	—	—
Kelvedon Wonder	26	66	4	98	—	—	0	92	—	—
Admiral Beatty ..	1	84	—	—	—	—	—	—	2	96
Early Bird ..	0	100	0	94	—	—	—	—	3	100
Clucas ..	7	88	0	84	—	—	—	—	—	—
Alderman ..	0	94	0	76	—	—	—	—	—	—
Miracle ..	4	86	0	94	—	—	—	—	—	—
Lincoln (3) ..	0	86	0	86	—	—	0	86	3	88
Pilot ..	10	100	0	84	—	—	—	—	0	88
King ..	14	*48	0	78	—	—	—	—	—	—
British Lion ..	2	84	1	92	—	—	—	—	—	—
Emerald ..	10	*70	1	86	—	—	—	—	—	—
Forerunner ..	17	92	—	—	—	—	—	—	—	—
Olympic ..	20	76	—	—	—	—	—	—	—	—
Pioneer ..	19	—	—	—	—	—	—	—	—	—
Phenomenon ..	13	—	—	—	—	—	—	—	—	—
Latest of All ..	9	—	—	—	—	—	—	—	—	—

* Heavily infected by species of *Penicillium*.

Also examined :—

Variety.	Canada.		U.S.A.		France.	
	A	G	A	G	A	G
Thomas Laxton (2)	1	96	—	—	—	—
Onward (2) ..	0	94	—	—	—	—
Onward (4) ..	—	—	0	100	—	—
Gradus ..	—	—	0	94	—	—
Admiral Beatty ..	—	—	—	—	0	96

the semi-arid western parts was practically free from *Ascochyta* sp, while seed produced in the wetter, eastern parts, where conditions are more favourable for disease development, was infected to a greater or less extent.

The germination tests showed that heavy seed infection may reduce the viability of the seed sample considerably but the results were some-

what variable. In isolated cases heavy infection did not cause much reduction in percentage germination, as for example in the first stock of the variety Onward, where 80% of the seeds of a sample which showed 47% infection germinated.

Similar results were obtained in tests made in boxes of soil in a cold greenhouse. These are shown in Table II.

TABLE II.

PERCENTAGE GERMINATION OF ENGLISH AND FOREIGN STOCKS OF VARIOUS VARIETIES OF PEAS IN STERILISED AND UNSTERILISED SOIL.

Variety.	Source.	Sterilised Soil.	Unsterilised Soil.
Foremost (1)	England	66	40
	Hungary	84	65
Foremost (2)	England	77	46
	Hungary	90	70
Foremost (4)	England	68	36
	Hungary	83	61
Thomas Laxton	England	71	25
	Hungary	95	56
Onward (1)	England	76	12
	Morocco	86	30
Onward (2)	England	90	46
	Canada	93	51
Gradus	England	82	46
	Hungary	93	62
Kelvedon Wonder	England	70	12
	New Zealand	98	49

The results of the sterilised soil series are comparable to those obtained in the germination tests in moist sand. In the unsterilised soil series, pre-emergence damping off reduced the percentage germination but did not alter the effect of the differences in the amount of *Ascochyta* infection between each pair of samples. In fact there was a greater relative reduction in the English samples than in the foreign ones, and it is suggested that this may be due to increased susceptibility to damping off caused by the presence of *Ascochyta* infection.

Cultures were made from the majority of the samples and in all cases they were identified as *Ascochyta Pisi*. While it is well known that this fungus is more common than *M. pinodes* and *A. pinodella* it is surprising that not even one case of seed infection by these other organisms was observed which suggests that field infection by these two fungi may result more commonly from sources other than infected seed, such as infected debris or weeds (2). In this connection it is interesting that seventeen samples of seed from England examined by Jones contained only *A. Pisi* also.

Field Trial.

A trial was laid down to determine the significance of seed infection by *Ascochyta* under field conditions. The trial was carried out with one variety only, Foremost, this being the only variety available for the purpose. The stock used showed 48% infection by *A. Pisi*. In round-seeded varieties, of which Foremost is an example, it is possible to identify infected seeds with the naked eye with a fair degree of accuracy, and advantage was taken of this fact to adjust the percentage infection in different lots of seed so that samples were obtained containing respectively 5, 10, 20, 30, 40 and 50% infected seeds.

Four randomised plots were sown with each sample, each plot consisting of 5 rows of 100 seeds planted uniformly 1" apart and $1\frac{1}{2}$ " deep. The rows were 1' 6" apart. A distance of 6' was left between each plot. The plots were sown on April 9th and 10th and the seedlings were observed emerging a fortnight later. After a further period of a week, the number of plants in each plot was counted. The pods were picked on June 26th, when they were nearly all in a marketable state. The seedling counts and crop weights are given in Table III.

TABLE III.
EFFECT OF PEA SEED INFECTION BY *A. Pisi* ON STAND AND CROP WEIGHT.

A. Mean emergence from seed samples containing different percentages of infected seed.							
5%	10%	20%	30%	40%	50%	S.E.	
345	324	294	294	230	222	11.4	
B. Mean crop weight in lb. from seed samples containing different percentages of infected seed.							
5%	10%	20%	30%	40%	50%	S.E.	
17.31	17.62	15.62	15.12	15.68	13.31	1.34	

Owing to the hot, dry weather conditions during the growth of the plants the development of *Ascochyta* was checked and no observations could be made on the effect of the disease on the haulm and pods in the different plots. The trial did provide some information, however, on the effect of seed infection on the stand and on the resulting crop.

Regarding first the effect of infection on the stand there was a decrease in the number of seedlings which emerged corresponding with an increase in percentage infection of the seed. Statistical analysis indicated that the stand for the sample containing 5% seed infection was significantly greater at the 5% point, than the stands for those samples containing 20 and 30% infection, while the stands of the two latter samples were significantly greater, at the 1% point, than the stand for the sample containing 50% infection. Although alterations in the amount of seed infection had thus significantly affected the stand a similar analysis of the crop weight figures showed that although there was a decrease in crop weight corresponding with an increase in the amount of seed infection, there were no significant differences. This result may be due to a compensatory effect whereby the plants in the plots with a smaller population, being farther apart, were enabled to make more growth and to bear relatively heavier crops.

Discussion.

The investigation has demonstrated clearly that infection by *Ascochyta Pisi* may be very common amongst English-grown stocks of pea seed in certain seasons. Twenty-six of the twenty-nine English samples examined were infected, and, of these, eight showed 20% infection or over. In contrast only seventeen of the forty-three foreign-grown samples were infected. None of these showed more than 20% infection and only in isolated cases did the percentage infection exceed 10%. As far as the effect of seed infection on stand is concerned the experiments indicate that unless a stock carries more than 20% infection the stand is unlikely to be materially reduced. The results of the field trial suggest also that in the absence of further development of the disease beyond the stage of killing off seed and seedlings below soil level there may be no significant losses in crop from seed showing 50% infection compared with seed showing only 5% infection. In terms of the stand of plants there was no significant difference in crop weight, although in one case (50% infection) the plant population was only two-thirds as large as that in the other. If this is generally true it is an important point, and raises the question of the amount of seed necessary to secure an optimum crop. The writer is unaware of any work on the effect of alterations in seeding rate on crop weight, but it seems that experiments of this sort might profitably be carried out.

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THE PREPARATION OF DINITRO-ORTHO-CRESOL EMULSIONS.

By H. G. H. KEARNS and H. MARTIN.

Dinitro-ortho-cresol (D.N.C.) is winning favour as a winter wash ingredient. This cresol is only slightly soluble in water, but it is fairly soluble in mineral oil. This latter physical characteristic is fortunate as the combination forms a winter wash of ovicidal properties which gives results equal to those obtained by the separate application of tar and petroleum emulsions and which avoids the risk of bud injury that sometimes follows the application of combined tar-petroleum washes.

A concentration of 0.1 per cent. D.N.C. (*i.e.* 1 lb. per 100 gallons wash) ensures a high control of aphid and sucker eggs and, although lower concentrations may sometimes be used with satisfactory results, the higher one is recommended until the reliability of the lower strengths is proved. A concentration of not less than 3 per cent. of Grade E petroleum oil is necessary for a reasonable control of Fruit Tree Red Spider Mite (*Oligonychus ulmi*) and to ensure the satisfactory spreading of the D.N.C. on the bark and eggs. Five per cent. Grade E petroleum oil is essential for capsid bug control.

Both concentrations of oil can be used with safety within two weeks of bud-burst on all kinds of fruit. On plums the outstanding merit of the combined wash is that it controls aphid and red spider and also checks caterpillars. Three per cent. of oil is used except when the red spider attack is particularly severe or difficult to control. Apples may be similarly treated, but as previously stated if capsid bug must be controlled, 5 per cent. of oil is required.

These two concentrations may be conveniently met by preparing a concentrate which on dilution provides 0.1 per cent. D.N.C. and 3.0 per cent. of oil; if 5.0 per cent of oil is required this is simply obtained by the addition of the correct amount of a petroleum emulsion (Grade E) which has been prepared with the same emulsifier. This system of preparation has been employed on a large scale at the Research Station.

Preparation of the Emulsion Concentrate.

The dinitro-ortho-cresol is best dissolved in the oil heated in a steam-jacketed tank to about 95°C., at the rate of 1 lb. D.N.C. to each gallon of oil. The mixture is stirred until the cresol has dissolved and it is then pumped into further oil at normal temperature, so that each three gallons of oil contains 1 lb. of 100 per cent. D.N.C. The emulsifier is separately prepared by diluting one volume of concentrated sulphite lye (60° TW., *d* 1.3) with nine volumes of water. Each three volume lot (as originally measured out) of cooled oil and cresol is made up to

$4\frac{1}{2}$ volumes with the diluted sulphite lye. The mixture is constantly stirred by a mechanical agitator or by passage through a gear type pump of large capacity.

The agitated mixture is fed by gravity through a 5 in. Premier Colloid Mill or other emulsifying equipment. The emulsion should be of a light yellow colour and it may be necessary to mill it twice to ensure that all the oil has been emulsified. The emulsion as prepared above contains 67 per cent. oil, therefore $4\frac{1}{2}$ gallons made up to 100 gallons with water provide a concentration of 0.1 per cent. D.N.C. and 3.0 per cent. oil.

If 5.0 per cent. oil is required, it is only necessary to add 3 gallons of petroleum oil emulsion containing 67 per cent. of Grade E oil to each $4\frac{1}{2}$ gallons of D.N.C. emulsion before dilution with water. The petroleum oil emulsion is prepared in the same manner.

The preparation of D.N.C. emulsions should not be undertaken by growers for two reasons. Firstly, there is an element of danger in handling the neat cresol which is decidedly unpleasant. The compound is marketed commercially in the form of a powder, as "beans" and as a paste. To avoid danger to health and undue staining of the skin the dry material must be handled with care and it is necessary to wear a suitable type of industrial respirator and protective clothing. In bulk quantities the paste is most easily handled, as particles do not become dispersed into the air. Secondly the preparation of emulsions requires special equipment and knowledge to ensure success (1) and when incorrectly prepared emulsions may cause extensive damage to trees and bushes.

Storage of the Emulsion.

The emulsion containing 67 per cent. oil creams fairly rapidly, which results in a concentrated layer of emulsion collecting at the top and a thin liquor settling at the bottom of the containers. The emulsion is best stored in large open-topped, circular cisterns, fitted with tight covers. Before the emulsion is pumped off into smaller containers, it should be agitated thoroughly to make a homogenous emulsion. The emulsion is best prepared each season in order to avoid any corrosion of the container which might occur on storage for long periods. If long storage cannot be avoided it is wise to cover the metal surface of the storage bin with bitumen paint or a heavy water-pump lubricating grease.

Under all circumstances the emulsion must be agitated, preferably by stirring before dilution with water.

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WAR-TIME WINTER SPRAYING FOR THE CONTROL OF INSECT PESTS OF FRUIT.

By H. G. H. KEARNS and H. MARTIN.

A number of the principal insect pests of tree and bush fruits pass the winter in an egg stage on their host plants. For this reason considerable attention has been given for a number of years to the possibilities of controlling these pests by ovicides. Control measures which aim at killing the eggs offer a number of advantages; the insect is immobile, the absence of foliage on the tree during winter enables the spraying to be carried out very thoroughly at a time of year when more labour and time is available. Winter ovicides owe their toxicity either to contact action or to a "smothering" action which in some way interferes with the normal incubation of the egg so that the embryo perishes. The range of materials for winter wash manufacture is partly limited by the question of price and of those available in quality the more important are tar and petroleum oils. More recently dinitro-ortho-cresol and certain organic thiocyanates have become available.

Types of Available Winter Washes.

The principal types of winter washes are as follows:—

1. Tar oil emulsions.
2. Petroleum oil emulsions.
3. Emulsions of mixed tar and petroleum oils.
4. Emulsions of petroleum oil containing an organic thiocyanate or dinitro-ortho-cresol.

1. *Tar Oil Emulsions.*

Tar oil emulsions are now applied at low concentrations just sufficient to ensure the complete control of the eggs of Aphides and Apple Sucker, but they provide no control of Red Spider and very little of Capsid Bug eggs. Only washes conforming to the specification approved by the Ministry of Agriculture and Association of British Insecticide Manufacturers should be purchased and they must be used according to the maker's directions. The formula is based on the fact that 3 per cent. tar oil of the type approved will provide a commercial control of aphid eggs. It should be noted that the concentration of 3 per cent. oil is represented by $4\frac{1}{2}$ to $7\frac{1}{2}$ per cent. of proprietary emulsions. Tar oil emulsions are prepared in the form of either miscible oils or stock emulsions. Miscible oils are dark in colour (black fluids) readily pourable and easily mixed with water. They are prepared by the solution of suitable emulsifiers in the oil and generally speaking, they are not suitable for very hard or saline waters. The stock emulsions are usually of a creamy nature, brownish in colour and less fluid than the miscible type, but most

of them are easily pourable from drums. They are prepared from mixtures of oil and emulsifier which are converted into an emulsion by passage through a colloid mill or homogenizer. The wider range of emulsifiers which can be used enables the manufacture of stock emulsions suitable for use with very hard and saline water.

Tar oil washes, at the above-mentioned concentrations, also provide some control of Winter and Tortrix Moths and of the overwintering stem-form of the Woolly Aphis provided that the spraying is carried out thoroughly so that the wash penetrates into the cracks and crevices in the bark and at the base of buds.

2. *Petroleum Oil Emulsions.*

Petroleum oil conforming to specification Grade (E) is the ovicidal constituent of petroleum winter washes. The oil must be applied at a concentration of not less than 5 per cent. to provide a control of the eggs of Apple and Green Capsid Bugs and at not less than 3 per cent. for the control of the eggs of Fruit Tree Red Spider Mite. These petroleum oil emulsion washes applied before bud burst, especially at the higher concentration, also provide a control of the Winter Moths. They have no toxic action on aphids and sucker eggs.

The emulsions are prepared as miscible oils or as stock types. Many proprietary washes at $6\frac{1}{4}$ — $7\frac{1}{2}$ per cent. concentration provide a wash containing 5 per cent. of oil.

3. *Combined Emulsions of Tar and Petroleum Oils.*

Emulsions of mixed tar and petroleum oils are available and as they incorporate the ovicidal properties of the separate oils they avoid the necessity of double spraying. They must be applied at a concentration that provides the minimum percentages of the two oils recommended for application singly, namely, 3 per cent. of the approved type of tar oil and 5 per cent. Grade (E) petroleum oil. The total oil concentration then amounts to at least 8 per cent. which is equivalent to at least 10 per cent. of the wash concentrate of the proprietary washes. Miscible oils and stock emulsions of the mixed washes are available.

4. (a) *Emulsions of Petroleum Oil and Dinitro-ortho-cresol.*

Dinitro-ortho-cresol (D.N.C.) will kill the eggs of Aphis and of Apple Sucker when applied at concentrations as low as 0.1 per cent. The cresol cannot be used alone, but compounded forms are available in which it is dissolved in petroleum oil Grade (E). A wash containing 0.1 per cent. D.N.C. and 5 per cent. petroleum oil will kill the eggs of aphids, Capsid Bugs, Winter Moths and Red Spider. A concentration of 0.1 per cent. D.N.C. and 3 per cent. oil is sufficient for trees not attacked by capsids and also provides a fair measure of control of Red Spider eggs. These compounded forms are available as stock emulsions which readily stain the skin and nails a bright yellow colour.

(b) *Combined Emulsions of Petroleum Oil and Organic Thiocyanates.*

Organic thiocyanates, such as dodecyl rhodanate and butyl carbitol thiocyanate, are ovicidal to aphids and sucker eggs. They are conveniently prepared admixed with petroleum oil to form combined washes. The concentration of petroleum oil in the diluted wash must be adjusted to the amounts recommended for ordinary petroleum oil emulsion, namely 3 or 5 per cent. of oil.

Spray Programmes.

Spray programmes under war-time conditions require careful consideration in order to attain the maximum results at a time when labour is short and materials are costly and must be conserved. The following spray programmes are suggested to meet the requirements in the various types of plantations or orchards.

Apples.

If Capsid infestation is slight or non-existent and a satisfactory control of Red Spider can be obtained by petal fall washes, only a tar oil application is required. The wash can be applied from mid-December until mid-March but before bud burst.

If Capsid Bug infestation is appreciable or serious, or if extreme difficulty is experienced in controlling Red Spider, a wash of mixed tar and petroleum oils or a D.N.C. wash should be applied. Unless it is applied not later than mid-February the former wash is liable to cause bud injury in some seasons and in some orchards as it contains 8 per cent. of oils. The D.N.C. wash is preferably applied in early March and even as late as just before bud burst. But on no account must it be applied at or after bud burst for then an unsatisfactory control of aphids will result.

Either of these combined washes is recommended for cider and farm orchards.

Pears.

Caterpillar is usually the most serious pest of pears; severe aphid infestations are less frequent. A tar oil winter wash should be applied from late December until early February for aphid control. Caterpillar is best controlled by the inclusion of lead arsenate in post-dormant scab washes.

Plums.

Aphid, Fruit Tree Red Spider and Caterpillar are the most common pests of plums. Red Spider infestations are often severe and cause much more injury to the trees than is generally appreciated. If the plums are to be sprayed after petal-fall for the control of Red Spider or Plum Sawfly, a tar oil wash is sufficient in winter. This may be applied up to the end of January. If petal-fall spraying cannot be carried out or if Red Spider control is difficult, a D.N.C. wash containing

not less than 3 per cent. petroleum oil should be applied not later than the end of the first week in February. With the loose-scaled varieties, such as Victoria, it is better to spray not later than mid-January, but late spraying is preferable to no spraying as bud injury is never as serious as an aphid infestation.

Cherry.

Winter Moths and Black Aphid are the principal pests. A tar oil wash should be applied before the end of January to control the Aphid while the Moths may be controlled by efficient grease banding. The grease should be applied not later than the middle of October because the period for catching female moths occurs from early November until mid-December and again in March. The grease must be raked over regularly with a steel comb to expose a fresh surface at intervals of 10 days during the principal flight period of the moths to ensure satisfactory results. It should be remembered that the male moth can carry the female at least 3 feet from the ground level and the banding should therefore be as high as possible on the tree trunks.

Black and Red Currants and Gooseberries.

Aphides, Apple and Green Capsid Bugs are widespread and serious pests of currants and gooseberries. Capsid infestations on these crops increase very rapidly and a slight infestation in one season often develops into a devastating attack in that following. A failure to control these pests results in a serious check to the growth and cropping powers of the bushes for two seasons. If there are no signs of Capsid Bug infestation the application of a tar oil wash only is necessary, but if Capsid is present it is strongly recommended that a combined tar-petroleum wash should be applied at the concentrations recommended. The mixed wash or the tar oil wash can be applied up to just before bud burst. Late applications on gooseberries also serve to protect the buds from damage by finches.

Raspberries, Loganberries and Blackberries.

These crops, particularly blackberries, are subject to attack by aphides. Generally it will be found necessary to spray the blackberries with a tar oil wash only. If the raspberries or loganberries are infested by Raspberry Moth, the spraying should be delayed until just before bud burst when the wash should be applied not only to the canes, but also very liberally on the ground around the stools. This treatment kills many of the moth larvae which have left or are about to leave their hibernating quarters to ascend the canes and enter the buds.

Capsid Bugs lay their winter eggs in loganberries and more frequently in blackberries. These plants are often the overlooked source of subsequent attacks on nearby currants and apples that have been carefully sprayed with Capsid washes. It is therefore wise when these crops are grown in orchards subjected to Capsid infestation to spray them with either a tar-petroleum wash or a D.N.C. wash containing 5 per cent. of petroleum oil preferably just before bud burst.

Fruit Grown with Vegetable Undercrops.

Under war-time conditions it may be desirable to undercrop the fruit with vegetables. This procedure will introduce complications in the spray programme, but it is important that the control of fruit pests and diseases should not be neglected on this account. The wash difficulty thus introduced is that the winter wash causes considerable damage to the vegetable crops.

The use of combined organic thiocyanates and petroleum oil washes materially reduces the risk of damage especially if the concentration of the oil applied does not exceed 3 per cent.

The Application of Winter Washes.

Winter washes should be carefully diluted and mixed according to the makers' instructions. In all instances it is advisable to agitate the contents of a barrel before using ; this is best done by running out into a larger container and then stirring. If this is not possible, violent rolling of the barrel may suffice. Inadequate attention is generally given to this important operation, for some separation of the constituents is certain to occur on prolonged standing, particularly in cold weather.

Spraying should be carried out in good drying weather. Rapid drying of the wash on the bark reduces materially the risk of bud damage. Spraying in windy weather is liable to cause an undue accumulation of oil on trees, often enough to cause bud damage. On no account should trees with wet bark be sprayed, as this dilutes the concentration of the wash, nor should spraying be carried out when there is a chance of the wash freezing on the bark before drying. The covering capacities of properly compounded miscible oils and stock emulsions are approximately the same.

It is of the greatest importance that winter washes of all types are applied thoroughly so that the bark is drenched, and care must be given to cover the smallest and most distant shoots of trees, a point of the greatest importance in the application of washes for the control of Capsid Bugs and Red Spider. The eggs of both these pests are laid in positions not readily wetted or reached by washes. Many of the reported failures of washes are due more to bad spraying than to faulty materials. Each spray man should either work out or be taught a definite method of spraying. A regular method of treating the trees or bushes saves fatigue and ensures better results. The men must be allowed adequate time for spraying each tree or bush.

The most economical method of obtaining rapid and efficient spraying is by the use of adequate-sized spray machinery. A spray man cannot apply efficiently and economically much more than 6 gallons of wash per minute. Whatever type of spray tackle is used, mains, semi-mobile or mobile, it is essential that the spraymen are not harassed. The mobile method of application in which the spray machine moves slowly with the men following it almost invariably results in unsatisfactory work. The close proximity of a moving machine does not permit of intelligent

treatment of each tree and portions of each are overlooked and remain unsprayed. Mobile outfits fitted with spray bars which eliminate the use of spraymen are generally only suitable for the treatment of bush fruit. If a mobile outfit is used for the fruit it should be fitted with hose lengths of about 75 ft. and stopped at convenient points allowing the spraymen to deal with a group of trees.

Winter washing is an unpleasant, tiring and skilled job. The spray team should be fitted out with clothing that protects them yet does not encumber them. Boiler suits with high collars, sou'westers and Wellington knee boots have proved the most practicable wear. Some of the washes are more unpleasant to use than others; D.N.C. sprays for example stain the skin, nails and clothing yellow. The liberal rubbing in of lanolin or vaseline on the skin of the face and hands before spraying avoids irritation and facilitates cleaning. Stain and odour can be fairly readily removed by washing with sulphonated lorol instead of soap.

Too much attention cannot be given to the importance of employing reliable men for one of the most important jobs on the fruit farm. The men should be encouraged to examine their spraying and correct each other.

SIMPLIFIED METHODS OF POTATO BLIGHT CONTROL : PROGRESS REPORT I—SPRAYING METHODS.

By R. W. MARSH and H. MARTIN.

Introductory.

In non-industrial areas where the potato is liable to Blight attack in July and August it is usually profitable to spray maincrop varieties with a copper fungicide. In order to popularise this spraying treatment among allotment and smallholders it is essential that the process shall be made as simple, as inexpensive and as foolproof as possible. The long-standing recommendation to apply Burgundy mixture with a knapsack sprayer involves more expense and trouble than the average small grower is prepared to undertake. Simplifications, both of materials and of methods, have been developed in recent years, and in 1940 these were tested at a number of centres throughout the country. The types of simplification employed may be summarised as follows :—

A. Simplified application—

- (i) Spraying : Replacement of knapsack spraying by sprinkling the fungicide from a watering-can.
- (ii) Dusting : Replacement of purchased dusting apparatus by a canister or muslin bag.

B. Simplified fungicides—

Replacement of Bordeaux or Burgundy mixture by compounded products requiring mere addition to water to produce the spray.

The present paper deals with trials of simplified spraying made on potatoes in the Bristol Province in 1940. Reference to simplified dusting is made in the succeeding paper by C. J. Hickman.

Experimental.

Materials.

The compounded copper fungicides now available for application as sprays are commonly preparations either of cuprous oxide or of copper oxychloride. For the trials described below two of the latter type and four compounded cuprous oxides were used. For comparison, either Bordeaux or Burgundy mixture was included at most trial centres. The complete list of the materials used is as follows :—

- (a) Bordeaux Mixture : home-prepared in the proportion of 10 lb. bluestone, 12 lb. hydrated lime to 100 gallon water.
- (b) Burgundy Mixture : home-prepared in the proportion of 10 lb. bluestone, 15 lb. washing soda to 100 gallon water.

- (c) Coppesan : a proprietary copper oxychloride preparation containing 47 per cent. copper.
- (d) Soltosan : a proprietary copper oxychloride preparation containing 50 per cent. copper and differing from (c) in the nature and content of dispersing agents.
- (e) Perenox : a proprietary dispersible cuprous oxide containing 50 per cent. copper.
- (f) C 40/29 : an experimental dispersible cuprous oxide containing 50 per cent. copper and differing from (e) in the nature and content of dispersing agents.
- (g) C 40/30 : a form of yellow cuprous oxide to which no supplementary wetting or dispersing agent had been added and containing 85 per cent. copper.
- (h) C 40/31 : a commercial red cuprous oxide made more easily wettable by the addition of a small amount of gum. The copper content was 83 per cent.

The last three products, being of an experimental nature, have been designated by code numbers and were, in most cases, used only in trials designed to compare fungicidal efficiencies. The remainder of the trials were intended for the comparison of methods of application.

Methods.

The conventional spraying apparatus used for comparison was a "Solo" bucket pump fitted with a nozzle giving a wide-angle misty spray. This apparatus was satisfactory for all the materials employed. For the process of sprinkling, a Haw's watering-can was preferably used, but various 1 gallon cans with fine roses were employed at various times. It was found that the watering-can was not satisfactory for applying Bordeaux mixture, as the orifices constantly became choked with particles of the suspension although this had previously been poured through cheesecloth. The remaining materials were applied without difficulty by the sprinkling method at rates approximately equal to those applied in spraying. As the output in sprinkling during a given time was much greater than that from the sprayer, it was important not to allow the jets from the watering-can to dwell too long on any one plant, but to carry out the sprinkling of a plot with reasonable rapidity. No purposeful effort was made to apply the spray from the watering-can to the undersides of the leaves, whereas in using the "Solo" sprayer the main intention was to apply the spray to the leaves from below.

Plots.

In the present paper, trials at six centres and some allotment trials are described. Two of the former were in the plantations of the Long Ashton Research Station, two in the parks under the control of the Bristol Corporation, and two in the county of Worcestershire. The Worcestershire trials were made by Mr. L. F. Clift, the County Instructor in Horticulture. The lay-out of the various trials was as follows :—

(1) *At Long Ashton: variety, Majestic.* In this trial a cuprous oxide spray was compared with a copper oxychloride preparation at three different strengths, all applications being by watering-can. Unsprayed plots were also included. The 49 plots were of the standard size (5 rows $\times$ 30 ft.) and were arranged in a Latin square. Details of the treatment were:—

A: Perenox 0.125% Cu.	D: Soltosan 0.25% Cu.
B: Soltosan 0.125% Cu.	E: Perenox 0.25% Cu.
C: Soltosan 0.09% Cu.	F: Unsprayed.
G: Perenox 0.09% Cu.	

(2) *At Long Ashton: variety, King Edward.* The trial was made up of 25 plots, 30 ft. long and 5 rows broad, comprising five treatments arranged in a Latin square. The trial was designed to provide a comparison between three cuprous oxide preparations applied by the sprinkling method. The lettering of the treatments was as follows:—

A: C40/31 at 0.4% Cu.
B: C40/30 at 0.15% Cu.
C: C40/31 at 0.25% Cu.
D: C40/30 at 0.25% Cu.
E: Perenox at 0.25% Cu.

(3) *At Blaise, near Bristol: variety, Majestic.* In this trial, spraying was compared with sprinkling, using three proprietary preparations at the same copper concentration. A Bordeaux sprayed treatment and unsprayed controls were also included. The plots were of standard size, but as the potatoes available formed a long strip only 20 rows wide it was necessary to divide this transversely into three blocks within each of which the following eight treatments were randomized:—

A: Soltosan sprinkled, at 0.25% Cu.
B: Coppesan sprinkled „
C: Coppesan sprayed „
D: Bordeaux sprayed „
E: Unsprayed „
F: Soltosan sprayed „
H: C40/29 sprayed „
K: C40/29 sprinkled „

(4) *At Oldbury Court, Bristol: varieties, Arran Banner and Gladstone.* This trial was another comparison between spraying and sprinkling, using both Bordeaux mixture and Perenox, at a strength of 0.25% Cu throughout. Each variety formed a strip 75 rows from north to south, 40 ft. from east to west. The variety strips were each cut into three blocks of five randomized treatments per block, the plot unit being five 40 ft. rows. The treatments were as follows:—

A: Perenox sprinkled, at 0.25% Cu.
B: Unsprayed
C: Perenox sprayed „
D: Bordeaux sprinkled „
E: Bordeaux sprayed „

(5) *At Worcester: variety, Majestic.* At this centre, Burgundy mixture was compared with Soltosan and Coppesan, all plots being sprinkled. Each plot was of 5 rows 40 ft. long and the whole trial formed a strip divided into three blocks in which these treatments were randomized:—

- A: Burgundy mixture, 10—15—100.
- B: Soltosan at 0.25% Cu.
- C: Coppesan at 0.25% Cu.
- D: Unsprayed.

(6) *At Perdiswell, near Worcester: variety, Arran Banner.* Here, Coppesan, Soltosan and Perenox were compared in a sprinkling trial using nine plots each 40 ft. by 5 rows. The treatments were:—

- A: Coppesan at 0.25% Cu.
- B: Soltosan ,,
- C: Perenox ,,

(7) *Allotment Trials.* In addition to these trials, five demonstrations of sprinkling versus spraying were made, in collaboration with the Advisory Mycologist, on allotments in the Bristol area. The demonstration allotments at (a) Long Ashton, of the variety Sharpe's Express, plots of Majestic at (b) Horfield, and at (c) Chapel Lane, and various plots at (d) Brislington were used for simple comparisons, five rows being sprayed, five rows being sprinkled and four or five rows being left untreated at each centre. The spray applied was C 40/29 at 0.25% copper.

Spray Applications.

Two applications were made in each trial excepting those in Worcestershire and on the Long Ashton Allotments. The dates of spraying at the various centres are summarised below:—

			<i>First Spraying.</i>	<i>Second Spraying.</i>
Centre	1	..	16 July	13 August
„	2	..	22 July	14 August
„	3	..	27 June	31 July
„	4	..	28 June	2 August
„	5	..	22 July	—
„	6	..	25 July	—
„	7a	..	25 July	—
„	7b	..	25 July	26 August
„	7c	..	25 July	15 August
„	7d	..	5 July	3 August

The standard plot, 30 ft. long 5 rows wide, required approximately 3 gallons per treatment at all centres, whether the application was by sprayer or by watering-can. The somewhat larger plots at centres 4, 5 and 6 required $3\frac{1}{2}$ —4 gallons. In the plots at Centre 4, which were exceptionally vigorous, a considerable amount of damage to the haulms was unavoidable during the second spraying, but this was no worse on the sprinkled than on the sprayed plots.

Weather.

All the spray applications were carried out on dry calm days, so the initial retention of the fungicides was not affected by wind and rain. The period between the two sprayings, however, was one of exceptionally heavy rainfall, the total recorded at Long Ashton during July being 7.92 inches. This rain fell mostly as heavy showers, and in spite of the heavy precipitation the month was not characterised by long periods of high humidity. In August a period of drought set in and from August 1 to September 7 only 0.19 inches of rain were recorded.

Results.

From the meteorological data recorded above it is evident that conditions were throughout unfavourable to the spread of *Phytophthora* and at most centres no evidence of the disease was found. At others, blight lesions were observed towards the end of August, but the disease never became more destructive to the haulm than did the drought. Direct evidence of the relative efficiency of sprinkling versus spraying or of the various copper preparation is therefore scanty, but indirect evidence was obtained by means of spray residue estimates.

Spray Retention and Tenacity.

Fungicidal efficiency is determined not only by the precise form of copper fungicide present on the leaf and its distribution on the upper and lower leaf surfaces, but by the amount of copper retained on the haulm throughout the period of possible infection. Estimates of copper retention were therefore made by foliage sampling by the methods described in previous papers (1).

The estimates obtained expressed as units representing one-tenth milligram per 50 leaf discs of diameter 1.4 cm. are included in Tables I—IV.

TABLE I.
COPPER ESTIMATES: TRIAL 1.

Sprayed.		22/7		16/8
Leaves Sampled.		23/7	15/8	17/8
Perenox 0.25% Cu	..	10.6	2.6	12.0
		9.8	2.8	10.8
		8.8	4.0	12.4
do. 0.125% Cu	..	7.4	1.6	8.4
		7.5	1.0	6.6
		6.0	2.2	—
do. 0.09% Cu	..	6.4	2.3	6.0
		6.8	2.1	6.2
		5.4	2.2	7.4
Soltosan 0.25% Cu	..	6.8	1.8	7.2
		9.4	1.4	8.2
		8.4	2.4	8.4
do. 0.125% Cu	..	4.9	1.2	4.0
		3.9	1.3	3.4
		—	1.3	3.8
do. 0.09% Cu	..	3.8	1.3	4.1
		2.8	1.35	3.2
		4.4	1.15	3.6

TABLE II.
COPPER ESTIMATES: TRIAL 2.

Sprayed.		16/7		13/8
Leaves Sampled.		17/7	12/8	15/8
Perenox 0.25% Cu ..	{	9.2	2.3	10.8
		8.4	1.2	10.4
		6.8	2.2	11.6
C 40/30 0.25% Cu ..	{	12.0	2.4	9.6
		9.4	2.7	8.8
		10.4	3.3	9.6
do. 0.15% Cu ..	{	7.4	1.7	7.2
		7.6	2.25	5.6
		6.6	1.7	5.2
C 40/31 0.4% Cu ..	{	13.8	3.9	11.2
		11.8	3.3	11.6
		15.3	3.7	8.4
do. 0.25% Cu ..	{	8.2	1.0	10.4
		—	3.1	10.2
		7.8	1.7	12.2

TABLE III.
COPPER ESTIMATES: TRIAL 3.

Sprayed.		27/6		31/7	
Leaves Sampled.		2/7	30/7	1/8	26/8
Coppesan	{ Sprayed ..	16.4	2.3	19.2	13.4
		16.3	2.3	17.2	10.0
		16.6	2.6	18.8	10.4
	{ Sprinkled ..	14.0	0.9	17.6	10.0
		14.0	0.55	17.6	9.2
		13.6	—	14.8	—
Soltosan	{ Sprayed ..	15.6	2.3	15.6	8.4
		14.6	2.7	14.8	10.2
		13.5	2.2	14.6	8.4
	{ Sprinkled ..	10.7	0.3	12.6	7.8
		12.4	0.9	14.2	9.8
		12.0	1.5	14.8	10.2
C 40/29	{ Sprayed ..	15.6	2.9	16.4	14.4
		20.5	2.6	13.2	10.8
		16.5	2.8	14.8	10.0
	{ Sprinkled ..	11.8	0.9	17.6	10.4
		13.9	0.9	18.4	12.8
		13.9	—	17.2	11.2
Bordeaux, Sprayed ..	{	23.2	5.5	17.6	14.4
		24.4	6.6	20.8	15.6
		27.4	—	20.0	16.4

TABLE IV.
COPPER ESTIMATES: TRIAL 4.

Sprayed.		28/6		2/8	
Leaves Sampled.		1/7	30/7	5/8	27/8
Perenox	Sprayed ..	{ 14.6	0.9	9.6	6.0
		{ 14.9	1.0	9.2	4.8
		{ 14.8	1.1	—	—
	Sprinkled ..	{ 12.3	0.7	10.4	8.0
		{ 9.4	0.55	11.6	9.2
		{ —	0.9	9.6	9.2
Bordeaux	Sprayed ..	{ 15.2	2.1	11.2	6.5
		{ 16.4	2.05	11.0	7.0
		{ 15.2	1.9	—	8.2
	Sprinkled ..	{ 11.3	0.8	10.0	4.8
		{ 10.5	1.2	10.4	4.0
		{ 13.1	0.6	—	8.1

(a) *Spraying versus Sprinkling.* Evidence of the initial retention is obtained from the samplings in Trials 3 and 4 taken soon after application, which yield the mean and significant differences recorded in Table V.

TABLE V.
MEAN ESTIMATES OF INITIAL RETENTION.

Sampling Date.	TRIAL 3.		TRIAL 4.	
	2/7	1/8	1/7	5/8
Sprayed	16.18	16.07	15.18	10.25
Sprinkled	12.92	16.09	11.32	10.40
Significant difference (P = 0.05)	1.31	1.19	1.59	2.25

The only difference shown is in favour of spraying at the earlier applications. In the case of Trial 4 this difference could be explained by the greater amount of liquid applied to each plot, which on 28/6 was $2\frac{1}{2}$ gal. when sprinkled and 4 gal. when sprayed. Whereas at the second application (2/8) the sprinkled plots each received $2\frac{1}{2}$ gal. and the sprayed plots 3 gal. In Trial 3, however, equal amounts were applied to both sprayed and sprinkled plots. An additional reason for the difference may therefore be that in sprinkling at the early date less of the spray hit the leaf surface than from the better directed spray nozzle. At later dates the growth of the haulm enabled a less wasteful application of the spray from the watering-can nozzle.

An indication of the relative tenacities of the spray deposits obtained by spraying and by sprinkling is given by the residue figures obtained some four weeks after application in relation to those soon after application. At the second sampling (12/8 and 15/8 in Trials 3 and 4 respectively) the residue figures are low, due to the rich development of haulm since the previous sampling. The analysis of the results is summarized in Table VI.

TABLE VI.
MEAN ESTIMATES AT THE SECOND SAMPLINGS.

Sampling Date.	TRIAL 3.		TRIAL 4.	
	30/7	26/8	30/7	27/8
Sprayed 	2.52	10.67	1.508	6.50
Sprinkled 	0.84	10.17	0.792	7.19
Significant difference ($P = 0.05$) 	0.35	1.61	0.247	1.85

The figures indicate a significant difference in favour of spraying only at the first application, a difference which may be associated with the greater amount of copper initially retained. There is, therefore, no evidence that the tenacity of the residue applied by sprinkling mainly to the upper leaf surface is inferior to that of the residue by spraying applied mainly to the lower leaf surface.

(b) *The Relative Efficiencies of the Products Used.* As potato haulm is easily wetted by water, differences in initial retention due to differences in the wetting properties of the sprays applied are small enough to be ignored. The copper estimates on foliage sampled soon after application will therefore reflect the copper content of the spray applied and, in those trials in which products were used at more than one concentration, a linear relationship can be assumed. The mean figures and significant differences quoted in Table VII for Trials 1 and 2 were calculated on this basis.

The validity of this assumption is illustrated by the low $(\text{Chi})^2$ values obtained in the calculation of the regression lines, the constants of which are assembled in Table VIII and by the observation that, with two exceptions, the origin lies within the zone of error of the regression line. These two exceptions, Perenox on Aug. 17th and C 40/31 on Aug. 15th, concern spray deposits in which the residue from the first application is a complicating factor ignored in the calculation. The limits of error ($P = 0.05$) of the mean in Trials 3 and 4 were calculated by the analysis of variance of the observations compared.

TABLE VII.
MEAN COPPER ESTIMATES SOON AFTER APPLICATION.

Sampling Dates.		TRIAL 1.		TRIAL 2.		TRIAL 3.		TRIAL 4.	
		23/7	17/8	17/7	15/8	2/7	1/8	1/7	5/8
Product.	% Cu.								
Soltosan	0.25	8.17 ± 1.32	7.90 ± 1.00	—	—	13.13	14.43	—	—
do.	0.125	4.58 ± 0.82	4.24 ± 0.53	—	—	—	—	—	—
do.	0.09	3.57 ± 0.97	3.14 ± 0.67	—	—	—	—	—	—
Coppesan	0.25	—	—	—	—	15.15	17.53	—	—
Percnox	0.25	9.73 ± 1.03	11.68 ± 1.16	8.10 ± 1.95	10.90 ± 0.98	—	—	13.20	10.00
do.	0.125	6.97 ± 0.66	7.73 ± 0.78	—	—	—	—	—	—
do.	0.09	6.20 ± 0.83	6.42 ± 0.95	—	—	—	—	—	—
C 40/29	0.25	—	—	—	—	15.37	16.26	—	—
C 40/30	0.25	—	—	10.60 ± 1.60	9.00 ± 2.45	—	—	—	—
do.	0.15	—	—	7.20 ± 1.60	6.33 ± 2.45	—	—	—	—
C 40/31	0.40	—	—	13.65 ± 2.65	10.40 ± 2.81	—	—	—	—
do.	0.25	—	—	8.00 ± 3.25	10.94 ± 2.81	—	—	—	—
Bordeaux	0.25	—	—	—	—	—	22.23	13.62	10.65
Significant difference (P = 0.05)		..	..	..	..	1.68	1.53	1.59	2.25

Both Dates
Sprayed
Plots only.

TABLE VIII.
REGRESSION CONSTANTS OF COPPER RETENTION FIGURES.

Sampling Date.	TRIAL 1.						TRIAL 2.					
	23/7		15/8		17/8		17/7		12/8		13/8	
	Soltosan.	Perenox.	Soltosan.	Perenox.	Soltosan.	Perenox.	C 40/30	C 40/31	C 40/30	C 40/31	C 40/30	C 40/31
$\bar{x}$ = Mean Copper Content of Spray	0.15875	0.155	0.155	0.155	0.155	0.15875	0.20	0.34	0.20	0.325	0.20	0.325
$\bar{y}$ = Mean Copper Retention Figure	5.55	7.633	1.467	2.311	5.10	8.725	8.90	11.38	2.342	2.7833	7.667	10.67
b =	28.754	22.097	4.018	7.538	28.657	32.778	34.00	37.56	9.167	11.33	26.67	-3.556
$(Chi)^2$ =	5.339	0.938	0.566	3.059	2.698	4.194	4.00	6.247	0.621	2.165	8.660	0.29
$V(a)$	0.111	0.065	0.009	0.0485	0.0428	0.0874	0.1667	0.416	0.0259	0.135	0.3611	0.345
$V(b)$	21.476	13.80	1.904	10.294	9.081	16.869	66.67	77.12	10.35	16.04	166.7	61.41

If differences ascribable to wetting properties can be ignored the initial retention figures should coincide with similar spray rates and copper concentrations. In a number of cases, however, a significant difference is apparent in the initial amounts of copper residues. Thus in Trial 3 the residue for Bordeaux exceeds that from the proprietary products, while that from Soltosan at both 0.125 and 0.09 per cent. copper is less than that obtained with Perenox. The probable explanation of these differences is that though the sprays were prepared to yield sprays of the stated copper concentration, the actual spray applied was of a lower concentration due to faulty dispersion and to differences in rates of settling of the spray suspensions. The validity of this explanation is being tested in the laboratory.

Conclusions on relative tenacity based on comparison of the estimates of spray residue of foliage sampled some weeks after application involves the assumption that the spray has not differentially affected growth rate. There was no visual indication that the relative high figure for Bordeaux residues obtained on July 30th in Trials 3 and 4 was associated with restricted growth which would explain why the difference was not revealed after the second application. It is, on the other hand, possible that the Bordeaux residue survived the heavy showers of July better than did the residues from the proprietary sprays, no marked differences in tenacity being apparent after the dry weather of August.

In the case of the products sprayed at more than one concentration of copper, as in Trials 1 and 2, an estimate of the relative tenacities is obtained by the comparison of the slopes of the regression lines, indicated by the statistic "b" in Table VIII. As there is no significant difference between the "b" values of Soltosan and Perenox on July 23 or Aug. 15, nor between those of C 40/30 and C 40/31 on July 7 or Aug. 12, there is no difference in the ratios. No significant difference in the tenacities of the residue yields by each of each pair of products is therefore observable.

Blight Control.

Throughout the season blight lesions were observed in only three of the trials, in which estimates of blight infestation on the scale used in earlier trials were taken periodically.

In Trial 7a but one estimate, on Aug. 5, was possible before the lifting of the early variety planted. On the two unsprayed plots, the blight estimates were 4 and 2 on the scale; on the plots sprinkled with C 40/29 at 0.25% copper they were 2 and 1; on those sprayed with the same mixture, they were 1 and 1. The indications are that the cuprous oxide, whether sprinkled or sprayed, reduced blight infestation.

In Trial 1 three estimates of blight infestation were made on Aug. 19, 28, and on Sept. 6, though on the latter occasion withering of the haulm by drought seriously affected the reliability of the estimates. The sums of the twenty-one estimates for each treatment, that is from seven plots on three occasions, varied between 11 and 25, whereas that of the

unsprayed plots was 69. The records, though too incomplete for detailed examination, thus indicate that all treatments have delayed the extension of blight infestation. On Sept. 30th, a final survey was made in which the amount of green haulm per plot was assessed regardless of whether the remainder had been killed by drought or by blight. Whereas the sum of the seven plots per treatment was between 22 and 14 that of the untreated plots was 4, a result which does not suggest that the treatments have, by phytocidal action, accelerated the effects of drought.

In Trial 2, estimates of blight infestation were possible only on two dates before drought intervened. The totals of the ten estimates per treatment were:—A, 12; B, 6; C, 14; D, 5; E, 2. The paucity of observation and the absence of unsprayed plots prevent conclusions on the efficiency of the treatments, but the generally high figures of Treatments A and C in both of which the product C 40/31 is concerned, suggest that this material is relatively inferior to C 40/30 (Treatments B and D) and Perenox (Treatment E).

At none of these three trials was it deemed worth while to take yield records.

Phytocidal Action.

Injury to potato foliage by copper sprays may be due to high phytocidal tendencies of the copper derivative used and, in the case of Bordeaux and Burgundy mixtures, has been ascribed to atmospheric pollution sometimes found in industrial areas and to the aggravation of phytocidal action resulting from severe aphid infestation of the haulm.

Evidence of differential phytocidal action was obtained in Trial 5, in which, a few days after application, small angular necrotic spots on the leaves appeared on some of the plots treated with Burgundy mixture and with Soltosan.

This damage did not extend further on the leaves and the crop records showed no reduction in yield on the affected plots. In no other trial were symptoms of acute phytocidal action observed with any of the products used, but general observation agreed that plots receiving the cuprous oxide sprays yellowed more rapidly towards the end of the season than did those sprayed with Bordeaux mixture. In spite of heavy aphid infestation which developed in most of the allotment plots (Trial 7) no sign either of acute or chronic phytocidal action was seen on the sprayed and sprinkled rows, which, apart from evidence of spray residues, were indistinguishable for the untreated rows.

Summary.

To simplify blight control in allotments and private gardens the substitution of a watering can fitted with a fine rose for a sprayer and of compounded products for Bordeaux or Burgundy mixture was examined in a series of trials.

Sprinkling from a watering-can was much quicker and easier than spraying except in the case of Bordeaux mixture which tended to block the holes of the rose. The amount of spray used in sprinkling need not be greater than that normally applied in spraying.

Owing to weather adverse to *Phytophthora infestans*, but slight evidence of the relative efficiencies of the methods of application or of the products used was obtained, the indications being that blight control can be obtained by sprinkling even though no attempt was made to cover the underside of the potato leaves.

The deposit obtained by sprinkling was equal in amount to that obtained by spraying except at early dates of application before the full development of haulm. No evidence was obtained that the deposit obtained by sprinkling is deficient in tenacity.

The deposit given by the compounded products is slightly smaller in amount than that given by Bordeaux mixture when equal amounts of spray of the same copper content are applied, a possible explanation being the less perfect dispersion given by the compounded products.

Acknowledgments.

The trials at Blaise and Oldbury Court were made by permission of the Bristol Corporation Parks Committee. The authors express their thanks to Messrs. J. P. Inglis (Parks Superintendent), W. C. Lowe and L. F. Watkins for the facilities and assistance so readily given at these centres. The Worcestershire trials were carried out entirely by the County Horticultural Superintendent, Mr. L. F. Clift, whose co-operation is gratefully acknowledged.

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SIMPLIFIED METHODS OF POTATO BLIGHT CONTROL :

PROGRESS REPORT II—DUSTING METHODS.

By C. J. HICKMAN, M.Sc.,

Scientific Officer, Agricultural Research Council.

With R. W. Marsh and H. Martin the writer co-operated in trials to test simple, inexpensive methods of potato blight control, suitable for use on allotments and small-holdings. The writer's trials were confined to the application of dust fungicides, the object being (1), to compare the results from using a home-made dust distributor with those using a machine specially designed for the purpose and (2), to compare, at equal copper content, the effect of a dust containing the insoluble cuprous oxide with one containing the soluble copper sulphate monohydrate.

The home-made dust distributor was a cylindrical tin, 6" long and 4" in diameter, in the bottom of which holes $1/25$ " in diameter were drilled approximately $1/4$ " apart, with a No. 60 wire gauge drill. Preliminary experiments with this duster showed that the dust ejected tended to settle in separate, small aggregates corresponding with the holes through which it issued. A more uniform distribution was obtained by covering the perforated end of the can with fine muslin, held in position by a rubber band. The dusting machine was a hand-operated, rotary blower manufactured by the Niagara Company.

The two dusts were made up with hydrated lime as a base. The cuprous oxide used was a grade known as Cuprocide G A, specially prepared for dusting. The copper sulphate monohydrate was prepared by heating the ordinary sulphate ($5 \text{ H}_2\text{O}$) to constant weight at 150°C . and afterwards passing it through a mill to grind it to a fine powder. The mixing of the copper compound with the hydrated lime was done in a small churn. Both dusts were made up to contain 15% by weight of copper.

Two trials were laid down in the vicinity of Bristol and another near Bromsgrove, Worcestershire. As the recording of the last-named trial was incomplete it is not discussed. At the Bristol centres the following treatments were applied to plots of 5 rows of potatoes, 30 feet in length, each treatment being replicated three times.

Copper sulphate monohydrate dust applied by home-made duster.

" " " " " " " machine.

Cuprous oxide dust applied by home-made duster.

" " " " " " " machine.

At one of these centres a spray treatment, one of those used by Marsh and Martin, was also included. This consisted of a cuprous oxide suspension in water (Perenox) applied from a watering can. Sufficient distance (approximately 15 feet) was left between plots to reduce "overlapping" of the treatments to a minimum. 8 ozs. of dust, containing approximately 1 oz. of copper, were applied to each plot, an amount equal to that given in the simplified spray application trial.

Three applications of the dusts were made between July 25th and August 19th. The spray treatment was carried out twice. After treatment random samples of 50 leaves were collected from each plot, usually on the following day and again before the next treatment. At each visit observations were made on the presence or absence of blight and of any injury to the foliage caused by the treatments.

Results.

Table I gives an estimate of the amount of copper present on the leaves on each sampling date. In the case of the samples collected on July 29th copper determinations were made per unit area (77 sq. cm.) of leaf surface, and in the case of the other samples the amounts present were determined as percentages of their dry weights. After measuring the area of samples of 50 leaves the amount of copper per unit area of 77 sq. cm. was then calculated. This was done to facilitate comparison of the dusting results with those of the spray treatments.

From a comparison of the percentage of copper and the amount per unit area in each sample it is apparent that there is a large experimental error, indicating the need, in future experiments of this sort, of taking much larger samples. It is clear, however, that the initial retention of the dusts was greater in the plots dusted with the home-made duster than with the machine, but there was no consistent difference in this respect between the two types of dust.

The very low figures for the first samples, taken only four days after the dusts were applied, are explained by the fact that an inch of rain fell between July 26th and 27th. Afterwards the total rainfall until September 10th was very small, amounting to only 0.35 inches.

At Centre A the variety treated was Gladstone, at Centre B, Majestic. It was noted that the copper sulphate dust killed all the haulm of the former variety by September 10th so that it was impossible to take samples, whereas on the variety Majestic there was little difference between the plots. Here copper sulphate injury was noticeable only as small necrotic areas on the leaf surface.

The trials supplied no information on blight control since the disease did not appear. The increase in initial retention on the plots treated with the home-made duster is probably due to the fact that in this process there is less chance of the dust being carried away by air currents, since it is not blown out and does not emerge as a cloud. Whether the increase in the amount of fungicide confers a greater measure of protection from blight is a point for further investigation. The machine duster gives a

uniform film of small particles whereas the home-made type deposits a relatively uneven cover of much larger particles and it is possible that the former deposit, although lighter, will be as efficient or more efficient than the latter. The importance of uniformity of cover and the particle size of dust fungicides has been stressed by Wilcoxon and McCallan (1) in their work on sulphur dusts.

Several disadvantages in the use of the home-made duster in comparison with the machine were noticed during the trials, viz. : (1) it was found that it took longer to apply a given amount of dust ; (2) a relatively small proportion of the dust reached the under surfaces of the leaves ; (3) a larger proportion of leaves remained virtually untreated.

Acknowledgment.

The writer is indebted to Mr. R. F. Batt who carried out the copper determinations recorded above.

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TABLE I.
COPPER RESIDUES ON FOLIAGE.

Date of Application.	Date of Sampling.	Centre A.			Centre B.		
		Home Made Duster.	Machine Duster.	Watering Can.	Home Made Duster.	Machine Duster.	
		Copper sulphate monohydrate.	Copper sulphate monohydrate.	Perenox.	Copper sulphate monohydrate.	Copper sulphate monohydrate.	Cuprous oxide.
July 25th-26th	July 29th ..	0.14 mgms.	0.20 mgms.	0.28 mgms.	0.16 mgms.	0.17 mgms.	0.18 mgms.
Aug. 6th ..	Aug. 7th ..	1.05% 3.42 mgms.	0.4% 1.19 mgms.	—	1.26% 5.42 mgms.	0.4% 1.45 mgms.	0.29% 1.22 mgms.
	Aug. 16th ..	0.036% 0.13 mgms.	0.03% 0.09 mgms.	0.0%	0.36% 1.32 mgms.	0.08% 0.31 mgms.	0.008% 0.03 mgms.
Aug. 19th ..	Aug. 20th ..	1.04% 3.6 mgms.	0.29% 0.93 mgms.	0.27% 0.8 mgms.	0.86% 3.37 mgms.	0.61% 2.21 mgms.	0.55% 2.28 mgms.
	Sept. 10th ..	Not sampled	Not sampled	0.14% 0.42 mgms.	0.24% 0.64 mgms.	0.07% 0.22 mgms.	0.26% 0.82 mgms.

NOTE. The percentages show the proportion of copper per dry weight of leaf sample.
The weights are the amounts of copper present per 77 sq. cm. of foliage.

A NOTE ON A *Lonchocarpus nicou* DUST FOR THE CONTROL OF THE CABBAGE WHITE BUTTERFLY.

By H. G. H. KEARNS.

The Cabbage White Butterfly is a well-known and widespread serious pest of many Brassica crops. The infestations occur in June and from August to early October. Attacks are generally most severe in autumn on crops growing in market gardens, allotments and gardens, and at times in the Southern Counties field crops may be severely damaged.

Young and full-grown larvae are readily killed by washes and dusts containing rotenone, but dusts are much more convenient and economical to apply. Most commercial dusts contain not less than 0.2 per cent. rotenone in the form of *Derris* or *Lonchocarpus*. A dust containing 0.1 per cent. of rotenone in the form of ground root of *Lonchocarpus nicou* has, however, given satisfactory control of the pest under field conditions and it would appear that this concentration is sufficient for this particular pest.

Preparation of the Dust.

A dust suitable for the treatment of Brassica foliage infested with larvae should have the following properties: it should flow readily from hand or power-driven blowers: it should settle on the foliage rapidly even if a slight breeze is blowing; and it should adhere to the foliage and larvae.

A dust consists of the toxic material thoroughly incorporated in a diluent to act as the carrier. The carrier may consist of a single material or of several, and in the latter case the physical properties of one component may be suitably modified by the addition of a small amount of a second.

Experiments on compounding dusts showed the following formula to be satisfactory for the treatment of Brassica crops:—

<i>Lonchocarpus nicou</i> (4 per cent. rotenone)	..	2½ lb.
Gypsum seconds mineral		92½ lb.
Amorphous silica dust		5 lb.

The *Lonchocarpus nicou* was finely ground so that the majority of it passed through a sieve of 200 mesh per linear inch.

The *Lonchocarpus* and silica were first mixed by rotation in a ball mill and then the gypsum was gradually added. The homogeneity of the dust was checked biologically. Experiments showed that homogeneity was very quickly attained and that a satisfactory dust could be made even in a converted hand-operated milk churn. The cost of material required to make 1 cwt. of dust was 14/-. Approximately 70 lb. of dust per acre were required to dust a crop in autumn.

A COMMERCIAL SCALE EXPERIMENT IN SUGAR RETENTION IN CIDER.

By VERNON L. S. CHARLEY and P. T. H. PICKFORD.

The Annual Report for 1939 contained an article dealing with the general principles of sugar retention in cider by means of racking, centrifuging or filtering processes, either alone or in association with SO_2 treatment. Following this, numerous enquiries were received from members of the cider industry for more precise details of the various treatments as they affected the storage of cider for natural conditioning in bottle. When it became obvious that the cider apple crop of 1939 would be extremely large, it was decided to confine the whole of the processing work in the cider house to large-scale tests of the various views that had been put forward from time to time as to the best methods of checking fermentation. At the same time, the decision was made to process as much fruit as the storage capacity of the cider house would allow, and this entailed a very considerable increase on the normal programme. The additional cider this produced was disposed of to cider firms during the late spring and early summer months.

It has proved to be difficult to draw up a concise table showing the actual behaviour of all the blends of cider, as several of them were withdrawn on various occasions for normal sales requirements, whilst others were sold in bulk. However, it has been possible to prepare a table which gives the data for the majority of the larger blends produced during the season. Figures are also given for the total quantities of cider of different gravities prepared on the bulk scale in 1939. These details have been extended by a closer examination of the effect of SO_2 in association with various treatments for yeast removal, and the effect of temperature on the fermentation of a single large bulk of cider.

Experimental.

A. Bulk Processing.

Processing in the Autumn of 1939 was divided into two clearly defined sections :—

- (a) Experimental work in which detailed attention was paid to problems such as the effect of the centrifuge versus the filter, or the effect of SO_2 addition on the subsequent rate of fermentation of the cider.
- (b) Tests in which the whole of the bulk of cider in any one experiment was treated in exactly the same way, *i.e.* usually a single centrifugation at a medium gravity (1.030–1.020).

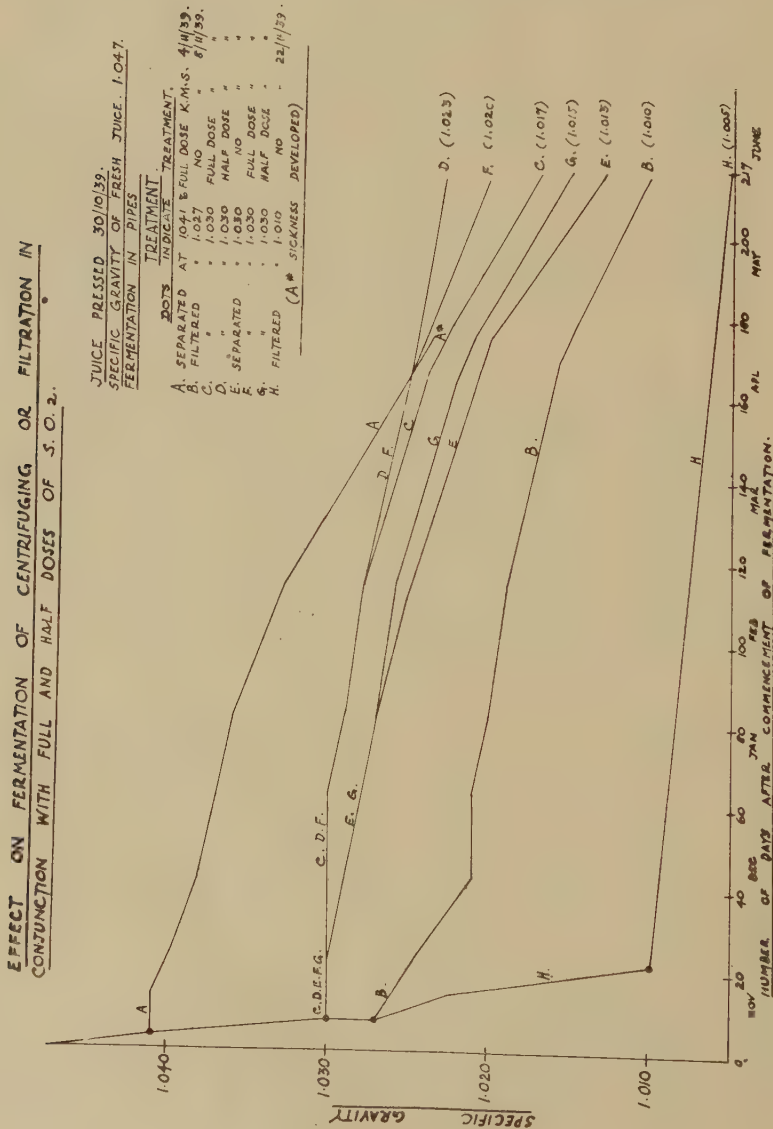
TABLE I.
STORAGE TESTS ON CIDERS MADE BY CHECKED FERMENTATION METHODS.

Experiment Number.	Dates of Making.	Volume of Juice in Gallons.	Original Gravity of Juice (or Centrifuged Cider.†)	Treatment.	Final Gravity at end of Experiment.	Date of taking Final Gravity.
4/39	1.11.39	1,000	1.048	C* at 1.030 on 9.11.39	1.027, 1.022, 1.018, 1.018, 1.018, 1.010, 1.010	26.4.40
5/39	3.11.39	660	1.051	C* at 1.029 on 15.11.39	1.024, 1.024, 1.024, 1.022, 1.017, 1.013	29.4.40
10/39	27.11.39	550	1.046	{ 9 ozs. K.M.S. added per 100 gals. on 22.12.40 .. } { C* at 1.028 on 5.1.40 }	1.0215	26.4.40
11/39	30.11.39	550	1.050	{ 9 ozs. K.M.S. added per 100 gals. on 22.12.30 .. } { C* at 1.020 on 1.1.40 }	1.015	6.3.40
12/39	6.12.39	440	1.049	C* at 1.031 on 13.12.39	1.023	16.4.40
15/39	12.12.39	1,100	1.046	C* at 1.029 on 19.12.39	1.020	18.4.40
16/39	15.12.39	1,000	1.040	C* at 1.029 on 22.12.39	1.022	6.3.40
18/39	28.12.39	400	1.045	C* at gravities between 1.033—1.025, between 8.1.40 and 16.1.40.	1.023	24.4.40
Vat 2	—	1,080	1.028†	Vat filled with centrifuged cider on 14.11.39 ..	1.020	4.6.40
3	—	1,080	1.022†	Vat filled with centrifuged cider (with 6 ozs. K.M.S./100 gals.) on 1.1.40	1.015	4.6.40
4	—	1,200	1.029†	Vat filled with centrifuged cider on 2.11.39 ..	—	4.6.40
“Ebon” tank	—	2,800	1.021†	Vat filled with centrifuged cider on 13.12.39 ..	1.0205	7.3.40

C* indicates Centrifugation at Gravity stated.

(a) *Effect of Various Methods of Checking Fermentation in Connection with the Use of SO_2 .*

1,000 gals. of juice were pressed out on 30.10.39. The specific gravity was 1.047, the rate of fermentation 6.8, acidity 0.33%, and the "tannin" 0.12%. The juice was fermented in pipes and either the fresh juice or the cider was centrifuged or filtered at various gravities. Associated with the centrifugation or filtration was the addition of either a full or half dose of SO_2 . The course of fermentation and storage is shown in Figure I, the key to the various treatments being included in the figure. There



is very little difference in actual sugar retention between the combined SO_2 treatments in association either with centrifuging or filtration. The best result was obtained by centrifuging the juice after a fall of 6 points in gravity and adding a full dose of SO_2 at this stage. The resulting fermentation was very slow and it is perhaps significant that sickness developed in the cider towards the end of April. The use of SO_2 has appreciably aided the retention of sugar in the ciders, although the effects of full and half doses are the reverse of the expected order in the filtering experiments. The SO_2 contents of the ciders were determined at the end of the experiment, 10.6.40, and were as follows :—

Cider :	A	C	D	F	G
SO_2 in parts per million. . .	109	117	67	120	67

The full dose of SO_2 allowed by law is 200 p.p.m., and this amount was added to ciders A, C and F. Ciders D and G had received 100 p.p.m. each. The final content of SO_2 in the ciders shows a very considerable depletion of the original amount, and in other experiments, the losses have been even larger.

(b) Effect of Double Doses of SO_2 on Fermentation.

In view of the considerable loss of SO_2 from cider preserved with this chemical, an experiment was carried out to test the possibility of adding much larger initial doses of SO_2 with the expectation that despite the inevitable loss a sufficient amount would remain to have the desired effect. Figure II gives all the necessary information regarding these experiments. The most satisfactory treatment was D, *i.e.* the fresh juice was allowed to ferment naturally to a gravity of 1.035 and was then centrifuged and treated with 400 p.p.m. SO_2 . The treatment associated with experiment E was the same as for D except that the cider on reaching a gravity of 1.035 was racked and then preserved with SO_2 . In this case, a centrifugation was carried out again at 1.023 on 17.4.40.

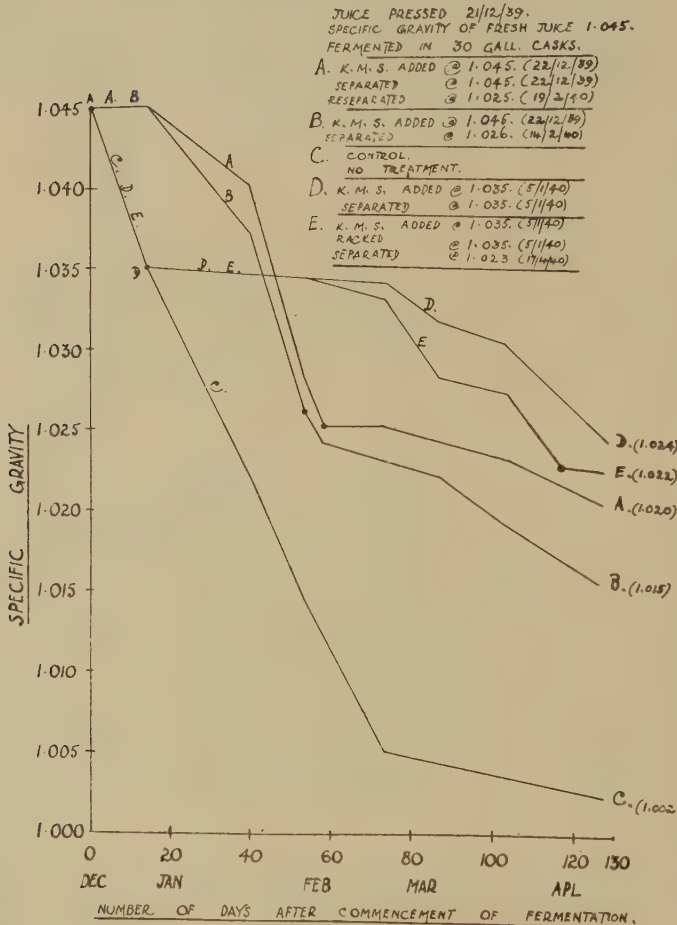
The addition of SO_2 after the original gravity had fallen by 10 points gave more satisfactory results with respect to maintenance of gravity than when the SO_2 was added to the fresh juice or to the fresh, centrifuged juice.

The SO_2 contents on 24.4.40 were as under :—

Cider :	A	B	D	E
SO_2 (in p.p.m.) . .	245	210	230	200

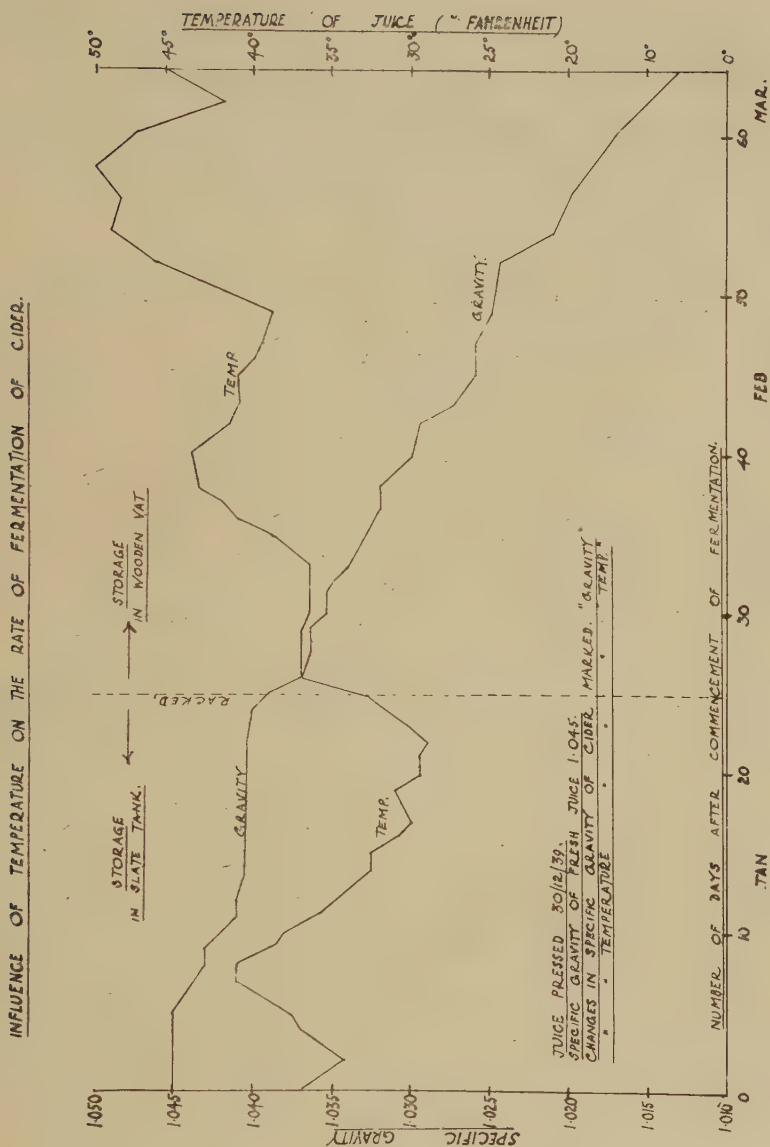
The retention of SO_2 would appear to be related to some function other than the time of addition of the SO_2 to the cider. The exact conditions under which SO_2 is retained or lost in fermenting and stored cider is being examined in the laboratory, as the large scale tests have proved to be unsuitable for the exact determination of the various factors.

EFFECT ON FERMENTATION OF DOUBLE
DOSES OF $S. O_2$ AT VARYING STAGES OF
FERMENTATION IN CONJUNCTION WITH CENTRIFUGING
OR RACKING



(c) *Influence of Temperature on Rate of Fermentation.*

The season of 1939-40 included many very exceptional changes in temperature and some data were obtained which gave an indication of the effect of temperature on rate of fermentation. 600 gallons of fresh juice were fermented in an open, slate tank on the ground floor of the factory and gravities and temperatures of the juice itself were taken at daily intervals. The cider was racked at a gravity of 1.040 and the storage was completed in a wooden vat. The time lag between the fall or rise in temperature and the corresponding decrease or increase in rate of fermentation can be seen from Figure III.



Summary.

1. A series of large scale, cider-making experiments were carried out in the 1939-40 season to test various methods of checking fermentation in cider and in retaining a considerable proportion of natural sweetness.
2. Straightforward centrifuging at a gravity of about 1.025-1.030 succeeded in retaining a very large proportion of the total stock of cider

in a sweet condition up to the end of April—a period that would be sufficiently long to enable the sweet cider to be bottled for natural conditioning.

3. These tests were extended to include various treatments with SO_2 and despite very large losses of the preservative when added in double, full or half doses, the presence of this chemical materially aided the efficiency of the ordinary centrifuge treatment.

4. The influence of temperature on rate of fermentation is shown by an experiment on 600 gallons of juice which was fermented during the very cold spell of January.

THE EXTRACTION OF RESIDUAL SUGARS, TANNINS, AND OTHER CONSTITUENTS FROM ONCE-PRESSED APPLE POMACE.

By VERNON L. S. CHARLEY and M. E. KIESER.

The need for the utmost efficiency in all the processes concerned in the cider industry has been accentuated since the War, more especially in view of the short crop of cider and market apples in 1940. It has long been an accepted fact that the normal pressing operations as carried out on the farm by screw presses is very inefficient in removing juice, and even the older type of hydraulic presses do not remove a very satisfactory proportion of the total juice. Twice-pressed apple pomace often contains as much as 60% of moisture and although the sugars and other constituents of this residual juice are not lost if the pomace is dried, circumstances can readily be imagined in which these soluble constituents of the apple would be better employed in the cider industry itself.

Consequently, the 1940 milling season at the Research Station was chiefly used for an investigation of the question of a more complete exhaustion of the apple tissue, and a series of bulk-scale experiments, using full scale cider-making plant, were carried out through the season on various lots of cider and cooking apples.

Apart from examining the amount of juice recoverable by means of second and third pressings of pomace, some preliminary experiments were carried out to indicate whether a process of "washing out" some of the soluble constituents by means of re-pressing the pomace in the presence of limited amounts of added water could be developed.

The results are given here and discussed chiefly from the practical point of view, although it will be seen that there are certain chemical facts reported for the first time that have important bearings on the scientific principles involved in extracting the various constituents of the apple. This is particularly the case with the data and observations on tannin. The importance of this constituent on the ultimate flavour of the cider necessitates a further examination of the problem of tannin changes during the milling, pressing and re-pressing operations and this will be undertaken at the earliest opportunity.

Experimental.

The data from the experiments are summarised in Table I.

Various lots of apples, including both cider and cooking types of fruit, were chosen throughout the 1940 milling season to represent the produce of different counties. The bulk weights given in the table are only

accurate to within about 1 cwt. and have not been corrected for loss in the washing machine. The general procedure was as follows:—The apples were tipped straight from the sacks into a rotary washing machine and conveyed to the grater mill by means of an elevator. The milled fruit was received into cloths separated by racks 40 ins. square. Twelve cloths constituted one "cheese" for which approximately 18 cwt. of apples were needed. The actual time to build the cheese was 20 minutes. By the usual system of interchangeable trollies one cheese was being pressed out whilst the other was being erected. The hydraulic press gave a total pressure of 120 tons on the ram and was operated at a final pressure of 2,500 lbs. per square inch on the cheese. The juice was collected until only a thin "pencil" flow was being recovered. The main bulk of juice was filled into pipes and the yield calculated from the known capacities of the pipes. Second and third pressings were measured accurately, in small graduated vessels. The once-pressed pomace was shaken from the cloth and set aside until the whole of the apples in the experimental bulk had been pressed. It was then passed through a pomace disintegrator and the material built up into a cheese as for the fresh pulp, the pomace being measured into each cloth to obtain even layers in the cheese. The pressing operation was exactly as before. Further pressings, either with or without water, were carried out in the same way, the pomace being disintegrated between each treatment. The water was poured into each cloth in the centre of the mass of pomace. In certain cases the water extracts were kept separate and fermented down in small casks, and the respective flavour changes noted in January 1941. The juice from the first pressings was mixed with that from the second pressings and fermented to about 1.025 and centrifuged.

One further point needs special explanation. During the milling process of single varieties of apples a "quick pressing" operation was carried out as follows. A small bag was half filled with the ground apple pulp as it was discharged from the mill and the juice pressed out in a laboratory press with the utmost speed. The maximum time elapsing between the actual milling of the apples and the collection of the expressed juice was half a minute. By this means it was hoped to obtain a truer idea of the percentage of the actual constituents of the juice than was given by the main bulk sample in which much oxidation had always taken place before the cheese could be pressed out.

Various deviations from the above general scheme are shown in Table I.

The last experiments 12 A F, were carried out with considerable accuracy, using hand-picked fruit, free from appreciable decomposition, which had been kept at 2°C. for a month. This was done to enable the results of the earlier experiments to be considered before actually commencing on the last available lot of cider fruit.

From the data set out in Table I the cider-maker will be able to see the main results of second pressings and of subsequent pressing with added water. There is no need to discuss these data in any detail but a few points of special interest will be mentioned.

(a) Yields of Pure Juice and Subsequent Pressing.

The yields of pure juice in gallons per ton of unwashed apples obtained from Experiments 3, 6, 9, 10, 11 and tabulated below to aid comparison.

No. of Experiment.	Type of Apple.	First Pressing.	Second Pressing.	Total.
3	Dorset Cider Apples	146	4	148
6	Kingston Black	150	16	166
7	Cooking Apples	142	7	149
9	Wiltshire Weepers	153	12	165
10	Knotted Kernel	146	16	162
11	Dabinett	152	17	169

The apples were all milled as near to maturity as possible with the exception of the Knotted Kernel fruits which were very over-ripe when received.

There appears to be no clear relationship between the yields obtained from the first and second pressings, but two of the lowest yields for the initial pressings (3 and 7) were accompanied by very low returns from the re-pressing treatment. The total yields were a little low—a feature of the 1940 pressing season.

It is difficult to devise a satisfactory basis for the presentation of the results of the re-pressing with water, but the figures indicate very clearly that :—

(i) When water is added the volume of expressed liquor is considerably in excess of the volume of water used.

(ii) The water itself, in addition to the above consideration, dissolves out of the pomace sufficient sugar, acid, “tannin,” pectin and flavouring compounds to convert it into a solution possessing most of the chief chemical and flavouring features of a genuine cider. Thus, the gain is a two-fold one, and the considerable total volume of the liquor obtained from the re-pressing with water will probably be of much interest to the cider industry. Lest the fear of undue dilution should be considered to be a detriment it should be pointed out that if the third pressings are mixed with the pure juice, the gravity of the latter is only very slightly reduced. A feature of the pressings with water was the very slow rate of fermentation shown by the re-pressed liquors, suggesting a low nitrogen content. For this reason it would be preferable to blend all the pressings from one lot of apples together previous to fermentation.

(b) Specific Gravities of Pressing.

Only very small differences of specific gravity were noted between the first and second pressings of pure juice and the differences were not in

the same direction in all the tests. The gravities of the pressings with water call for little comment, beyond the fact that they are in some cases as high as for pure juice of certain varieties.

(c) Acidities.

The acidities of the second pressings were practically the same as those for the first pressed juice, whilst very considerable residual quantities of acid were removed by the later water treatment.

(d) Calcium Pectate.

The estimation of this compound is a convenient way of assessing the amount of pectin material present in apple juice. It is not definitely related to any single chemical compound but is formed from pectin in various conditions and forms in the juice or pomace. It has been stated in the literature (1) that cold water soluble pectins are not satisfactory for the formation of jellies, and if this is so, the removal of relatively large quantities of pectinous substances in the water pressing cannot be considered as having a deleterious effect on the value of the residual pomace as a source of pectin. This point, however, is of some importance, and will be examined next season.

The removal of pectins was considerably greater in the second pressing of the pure juice than in the initial treatment, and the water washing extracted further appreciable quantities. This latter fact probably accounted for the presence in the water pressings of certain materials which contributed a viscosity to the juice which appeared to be practically the same as for the pure liquor.

(e) "Tannin."

The figures for "tannin" show the widest variations of all the separate constituents under review. The highest percentages were found in the quick pressings, and as the exposure of the pomace became progressively more protracted during the succeeding pressing, disintegrating, and repressing operations the "tannin" figures showed very considerable decreases. It has been pointed out in previous Reports that the "tannin" percentages would be more correctly designated as "permanganate-reducing substances" but as there is a very definite relationship between these figures for the juice extracted by the straightforward method and the astringency of the cider on the palate it is still the practice to refer to the results of the permanganate titration as "tannin" in the case of first pressings. The loss of "tannin" as shown by the titration, is always accompanied by a darkening in the colour of the pomace, and in some cases of the juice also. But the chief losses are always to be found where juice is exposed to the air in contact with pomace, the losses of "tannin" in expressed juice being relatively insignificant. Various tests were carried out to examine this point in further detail and although they will not be fully described here, allusion will be made to four small-scale tests.

(i) The pulp from 1 cwt. of milled Knotted Kernel apples was thoroughly mixed in an open cask and samples taken out at intervals and pressed out, the juice being immediately analysed for "tannin."

Time in hours after milling.	0	$\frac{1}{6}$	$\frac{1}{2}$	1	2	4	6	24	30	50	72
"Tannin" %	0.282	0.260	0.225	0.223	0.195	0.182	0.180	0.145	0.128	0.118	0.130

The figures show the very appreciable loss in permanganate-reducing power over a 72-hour period. Fermentation had commenced after the 50-hour period, and it is interesting to note that there was a slight recovery in the "tannin" figure after this period.

(ii) A series of large beakers were filled from a well-mixed mass of Dabinett pulp as it was discharged from the mill. The contents of each beaker were pressed out and the juice analysed, as above, at varying times.

Time in hours after milling.	0	$\frac{1}{2}$	2	20	72	10 (Days)
"Tannin" %	0.243	0.168	0.150	0.110	0.073	0.075

Even greater losses were observed in these experiments than in (i) above.

It was noticed that although the pulp very quickly became dark red in colour, the layer in contact with the bottom of the beaker, was still quite green, indicating that an oxidation process was probably responsible for the darkening and for the loss of permanganate-reducing power.

(iii) An experiment was devised in which some freshly milled apple pulp was stored in beakers for 24 hours with varying amounts of common salt. The separate lots were then pressed out and the juice titrated with permanganate. The control was mixed with the same volume of water as that of the salt solutions.

Treatment.							"Tannin" %
Quick press with water	..	..	..	..	..	..	0.105
Pressing after 24 hours	(Control)	..	..	..	..	..	0.064
" " " "	(0.02% salt)	..	..	..	..	..	0.087
" " " "	(0.01% ")	..	..	..	..	..	0.082
" " " "	(1.0% ")	..	..	..	..	..	0.082
" " " "	(2.0% ")	..	..	..	..	..	0.082

The admixture of salt appears to have inhibited the oxidation process to some extent. These experiments were extended to include other inhibiting agents, and good results were achieved, but as the results at the moment have only academic interest, they will not be discussed until a more practical outcome is apparent.

(f) Flavour Tests.

In several of the tests it was possible to compare the flavours of the products obtained by fermenting the mixed, pure juice pressings with those from the water pressings. The latter had been allowed to ferment practically to dryness in order to provide a reasonable alcoholic strength and consequently the comparison was between a medium-sweet and a dry cider. This difference in sweetness did not interfere with a full

appreciation of the major fact arising from these flavour tests, *i.e.* that despite the very large discrepancies between the "tannin" contents of the various products in each particular experiment, the flavours were by no means so widely different from each other. In other words, the loss of "tannin" as given by the permanganate-reducing figure for juices repressed from pomaces that have been exposed to the air for several hours, is not correlated with an equivalent loss of astringency in the cider. The suggestion has been made by Warcollier (2) that "tannin" is oxidised to a "tannin oxide"—a dark-coloured but somewhat unstable compound. It would appear that the oxidised form of tannin is incapable of reacting normally with permanganate but that it still retains its capacity of contributing an astringent taste to the cider. This point has been made previously by Pickford (3) who came to the same conclusion as a result of some experiments on maceration.

It is not desired to proceed further at the present stage of the work with a discussion of the chemical significance of this point, but the two features of chief importance which can be shown from these experiments are :—

(i) Permanganate-reducing figures give no idea whatever of the astringency of cider made from pomaces that have been exposed to the air for lengthy periods.

(ii) The loss of actual astringency in the processing of second pressings or pressings with water is only slight.

Summary.

1. The yields of pure juice obtained by second pressings of apple pomace are given.

They vary between 4 and 17 gallons per ton of unwashed apples.

2. Further extraction of residual, soluble, chemical constituents in the pomace can be affected by re-pressing the disintegrated pomace with the equivalent of two gallons of water per cloth containing 66 lb. pomace. The water releases further quantities of juice and itself extracts considerable quantities of sugar, acid, pectin and "tannin" materials from the pomace. The water extracts in many cases were fermented down alone and gave rise to ciders of soft, mellow astringencies.

3. Although the permanganate-reducing figures for special juices showed extremely large reductions on exposure of the pomace to the air (*i.e.* for second, third and fourth pressings), the astringency of the fermented extracts was not similarly reduced. The oxidation of the normal "tannin" to an oxidised form which does not reduce permanganate but which still contributes an astringency to cider is suggested as the cause of this phenomenon.

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- (3) PICKFORD, P. T. H. *Ann. Rept. Agr. and Hort. Res. Stn.*, p. 141. 1934.

TABLE I.

THE EFFECT OF VARIOUS METHODS OF EXTRACTION ON THE REMOVAL OF SUGARS, TANNINS, ETC., FROM APPLE POMACE AND ON THE FLAVOURS OF THE FERMENTED EXTRACTS.

No.	Fruit	Treatment	Date of Making	Total Water Added Galls.	Yield in Galls.	Tonnage	Analysis of Fresh Juice or Extract			Centrifuged Cider (23/1/41)			
							Specific Gravity	Acidity %	"Tannin" %	Calcium Pectate %	"Tannin" %	Flavour	Specific Gravity
1A	Somerset cider apples (mixed).	Milled & pressed at once (8 cheeses).	14.10.40	Nil	1000	6	1.057	0.52	0.165	0.060	0.150	Fair quality, soft but definite astringency	1.014
1B	"	D* : pressed out after 6 hours with 2 galls. water per cloth(64lbs. pomace).		24	54		1.036	0.34	0.030	0.075	0.025	Mild bitter character : quite a full flavour	1.002
1C	"	As for 1B, but allowed to stand with water for 12 hours before pressing.		24	52½		1.030	0.37	0.035	0.128	0.025	Much fuller flavour than 1B	1.004
3A	Dorset cider apples (mixed).	Milled & pressed at once (5 cheeses).	24.10.40	Nil	760	5.2	1.058	0.61	0.215	0.090	—	—	—
3B	"	D: re-pressed 2 hours later.		Nil	23		1.060	0.55	0.085	0.189	—	—	—
3C	"	D: re-pressed 1 hour later		Nil	7½		1.052	0.55	0.038	0.129	—	—	—
3D	"	D: re-pressed with 2 galls. water to each cloth of 66lbs. pomace.		24	49		1.040	0.42	0.036	0.127	—	—	—
3E	"	D: re-pressed with 4 galls. water to each cloth		48	70		1.030	0.31	0.023	0.114	—	—	—
6A	Kingston Black	Milled & pressed at once	6.11.40	Nil	360	2.4	1.077	0.87	0.200	—	0.208	Very strong flavour : penetrating acidity and astringency.	1.029
6B	"	D: re-pressed 4 hours later.		Nil	40		—	—	—	—	—	—	—
6C	"	D: re-pressed with 2 galls. water per cloth.		24	31		1.047	0.54	0.040	0.058	0.039	Soft, mellow cider with very pleasant astringency.	1.010
6D	"	D: " "		22	28		1.034	0.38	0.030	0.076	0.033	" "	1.005
7A	Cooking apples (mixed).	Milled & pressed at once (5 cheeses).	7.11.40	Nil	640	4.5	1.050	0.50	0.108	0.064	0.090	Thin : lacking in apple and tannin character.	1.001
7B	"	D: re-pressed 4 hours later.		Nil	30½		—	—	—	—	—	—	1.002
7C	"	D: re-pressed with 2 galls. water per cloth.		17	23		1.030	0.30	0.024	0.114	0.028	A useful cider : soft astringency.	1.002

Table 1 (Continued)

9A	Wiltshire Weepers (bitter- sweet cider apples).	Quick sample pressing.	18.11.40		1.3	1.058	0.11	0.222	0.089	—	—	—
9B	"	Main bulk milled and pressed at once.		Nil	268	1.058	0.17	0.215	0.077	0.179	Very full-bodied cider, but extremely soft astringency.	1.023
9C	"	D: re-pressed 2 hours later.		Nil	28	1.062	0.24	0.065	0.144	—	—	—
9D	"	D: re-pressed with 2 galls, water per cloth.		18	30	1.035	0.15	0.030	0.100	0.035	Clean mild bittersweet cider.	1.000
10A	Knotted Kernel	Quick sample pressing.	19.11.40			1.080	0.10	0.255	0.142	—	—	—
10B	"	Main bulk milled and pressed at once.		Nil	248	1.058	0.18	0.241	0.130	0.168	Strong bittersweet cider.	1.022
10C	"	D: re-pressed 4 hours later.		Nil	28	1.056	0.23	0.096	0.203	—	—	—
10D	"	D: re-pressed with 2 galls, water per cloth.		23	32	1.036	0.12	0.065	0.105	0.060	Still full flavour with mild astringency.	1.019
11A	Dabinett	Quick sample pressing.	6.12.40			1.048	0.17	0.233	0.195	—	—	—
11B	"	Main bulk milled and pressed at once.		Nil	264	1.047	0.23	0.180	0.122	0.165	Very pleasant, soft medium-bitter cider.	1.024
11C	"	D: re-pressed 4 hours later.		Nil	30	1.046	0.25	0.058	0.116	—	—	—
11D	"	D: re-pressed with 2 galls, water per cloth.		20	26	1.026	0.17	0.040	0.102	0.020	Lacking in character.	1.004
11E	"	D: " " "		20	24	1.019	0.14	0.023	0.090	0.025	Very poor.	1.003
12A	Dabinett	Quick sample pressing.	10.1.41			1.043	0.10	0.243	0.129	—	—	—
12B	"	1 gall. sample pressed quickly.		—	—	1.050	0.13	0.243	0.147	0.220	Slightly rough, full-bittersweet character.	1.020
12C	"	Main bulk milled and pressed at once.		Nil	16.5	1.051	0.10	0.173	0.158	0.158	Fully flavoured but more mellow than 12B.	1.021
12D	"	D: re-pressed 1 hour later.		Nil	1.25	1.051	0.095	0.075	0.183	0.090	" " " "	1.019
12E	"	D: re-pressed with equivalent of 2 galls, water per 64lbs. pomace		2	2.4	1.025	0.040	0.033	0.081	0.023	Much less flavour than B, C, D, but mildly bitter.	1.003
12F	"	D: " " "		1.5	1.75	1.020	0.020	0.033	0.073	0.023	Slightly less flavour than E, but still definitely astringent.	1.001

* D indicates passage through a pomace disintegrator.

CONCENTRATED APPLE JUICE AND TREACLE.

I. TECHNIQUE OF PRODUCTION.

II. A NEW METHOD TO PREVENT GEL FORMATION.

III. UTILISATION OF APPLE CONCENTRATE AND TREACLE.

By VERNON L. S. CHARLEY, D. P. HOPKINS and A. POLLARD.

The Annual Report for 1939 contained an article on concentrated fruit juice products with special reference to the apple. Although a certain amount of data was given, the article was presented in general terms and no actual experimental facts were recorded. Since that time, a great deal of interest has been shown in concentrated apple juice and the more highly concentrated treacle, both by firms who were desirous of producing the product and also by food manufacturers who wished to make use of the concentrated materials in their food processing. These complementary sources of inquiry have raised between them a number of specific points that could not have been foreseen until processing of concentrated juices and their utilisation in other processes became actual fact.

The results of the latest investigations are discussed in the appropriate sections of this Report, including an interesting feature of the work of very recent development which has not been previously mentioned. The production of treacles from cooking apples had previously been satisfactorily achieved only by means of pectin-decomposing enzymes, and during the Winter of 1940 the position was complicated by the shortage, and at one time the complete absence of the enzyme material which is only produced abroad. As a result of urgent representations from the trade, attempts were made to overcome this obstacle and it was discovered that the neutralisation process, if carried out under accurately controlled conditions, obviated entirely the need for the pectin enzyme.

Some experiments on the use of apple treacle are included, together with some recipes developed in the laboratory.

Finally, it should be mentioned that the investigations reported here have been extended in another direction not discussed in this article. It is suggested that manufacturers who are interested in the production of apple juice concentrates or treacle should communicate with the Research Station regarding the latest developments.

I. TECHNIQUE OF PRODUCTION.

A. Concentrated Apple Juice.

During the Winter of 1939-40, a programme of semi-commercial experiments was carried out on the concentration of fruit juices. For this purpose a small Kestner climbing filmt. triple circulation vacuum evaporator with a juice input of 8 gallons per hour was installed. The machine was fitted with a heating coil to warm the juice to 50-60°C. previous to its entry into a separator in which the volatile fractions were removed and condensed in a water condenser. The individual tests usually occupied three hours, but in some cases the plant was run for 12 hours a day for a period of several days. A number of widely differing varieties of apples were used and, thanks to the co-operation of fruit growers and packing stations in Kent and Essex, experiments were carried out on bulks of low grade apples that would normally be surplus. None of the fruit used would normally have been saleable through the ordinary fresh fruit trade.

A selection from the complete series of trials and the abridged results are given here :—

(a) Semi-commercial Tests.

Test 3.

Knotted Kernel, Bittersweet Cider Apple Juice. (Specific gravity 1.054 ; acidity, 0.24% ; "tannin," 0.26%.)

The juice was expressed with considerable difficulty on 20.11.39 and immediately pulp filtered to a brilliant condition. It was concentrated on 21.11.39 giving the following products to which the esters were returned :—

	Specific Gravity.	Consistency.	Clarity.	Flavour.
1.	1.330	Very thick, later developing lumps of jelly.	Brilliant.	Very bitter and sweet, strong fresh apple character.
2.	1.356	Firm jelly on cooling.	"	"
3.	1.290	Fluid.	Brilliant, becoming cloudy later on account of slight fermentation.	Slightly alcoholic flavour developed after several months.
4.	1.257	"	"	Strong alcoholic flavour, associated with an intensified fruity character.

The difficulties encountered in pressing the milled apples were probably associated with an abnormally high pectin content which was also responsible for the gelling in the concentrates with the higher gravities.

Fermentation occurring in a concentrate with a gravity of 1.290 indicates that the usual gravity for exported Canadian concentrated apple juice is not sufficient protection against fermentation in English apple concentrates.

Test 4.

Mixed Cooking Apple Juice.

The juice was expressed on 23.11.39, filtered to a brilliant condition and concentrated at 2 p.m. the same day. The process of concentration was extremely irregular owing to gel formation in the tubes. The steam pressure was maintained at 5-7 lb. per square inch, vacuum $27\frac{1}{2}$ " (barometer $29\frac{1}{2}$ ") and the juice heated to 54°C . in the coil prior to the ester separation, the heating bath being kept at 70°C . The following samples were collected with a view to observing the behaviour of various strengths of concentrate on storage. Esters were added to samples 1 and 2.

	Specific Gravity.	Consistency.	Clarity.	Flavour.
1.	1.126	Fluid.	Brilliant at first but very cloudy as fermentation ensued after a short period.	Completely spoiled by fermentation.
2.	1.209	"	"	"
3.	1.295	Firm jelly on cooling.	Brilliant.	Very attractive fresh apple flavour with only a slightly cooked taste.

This test illustrates the difficulty of dealing with cooking apple juice unless some treatment is given to alter its composition to prevent gelling both in the evaporator and during storage. The lower gravity products fermented after a few weeks, but it was not possible to arrive at any intermediate product between these samples and the material that set to a firm jelly on cooling. A further quantity of the same original juice was depectinised for Test 5.

Test 5.

Cooking Apple Juice (Depectinised).

The fresh juice was treated with 0.1% of pectin-decomposing enzyme for 24 hours and the juice cleared to a remarkable extent during this period. Concentrates with high gravities were prepared with ease and using the normal conditions for the ester separation (see Test 4) a quantity of volatile material was collected in a continuous manner and was re-distilled and returned at once to the concentrates in the correct proportions. In some cases the volatile fraction was added to only one half of the sample, the other half being kept as a control. Reference is made at the end of this section to the results of these comparative tests.

The following data refer to the samples from Test 5.

	Specific Gravity.	Consistency	Clarity.	Flavour.
1.	1.377	Fluid.	Clear, no deposit.	Very penetrating acidity but clean fruity character.
2.	1.340	"	"	"
3.	1.322	"	"	"

The removal of the pectin from the juice enabled the concentration to be taken to a very high figure without any difficulty—a marked contrast to the conditions under which Test 4 was carried out. No deposit was noted in the samples after 12 month's storage.

Test 7.

Mixed Cider Apples (Monmouthshire).

A very fine sample of cider apples were milled and pressed, the juice analysis being as follows:—Specific Gravity 1.046, acidity 0.62%, "tannin" 0.17%. The juice was filtered to a brilliant state but could not be concentrated sufficiently without gelling. Consequently the juice was enzymed for 48 hours with 0.1% enzyme after which concentration proceeded smoothly. Attempts were made to obtain very concentrated juices but the highest sample taken had a specific gravity of only 1.385. The incorporation of the esters in this material was only effected by continuous stirring but the final product was most attractive, although it was still too thin to be used for the purpose of a treacle. The acidity was high and constituted a possible disadvantage in cases where the product was being considered purely from a sweetening point of view.

Test 8.

Woodbine Cider Apple Juice.

For this test a low acid cider apple juice was taken (specific gravity 1.050, acidity 0.34%, "tannin" 0.24%). The juice was enzymed on 9.12.39 and filtered with ease. The conditions for ester separation and concentration were:—Steam 6-8 lb. per square inch; vacuum 27½" (barometer 30"); temperature of juice leaving heating coil 50°C.; temperature of heating bath 65-70° C. A series of high gravity concentrates were collected without difficulty and some details of observations taken after twelve months are given below:—

	Specific Gravity.	Consistency.	Clarity.	Flavour.
1.	1.360	Fluid.	Clear.	Strong bitter character would make this product too astringent for use by itself, but it would be most valuable for blending with cooking apple concentrate.
2.	1.327	"	"	"
3.	1.255	"	Cloudy after slow fermentation developed.	Spoilt by fermentation.

*Test 9.**Cox's Orange Pippin Juice.*

A consignment of low grade Cox's in sacks was obtained from Essex, and whilst the condition of the fruit was spoilt by very serious bruising there did not appear to be any appreciable decomposition of the fruit from the point of view of yeast or mould infection. The fruit was pressed with difficulty (this being a feature of the Cox apple in a ripe or over-ripe condition) and enzymed by the usual method on 14.12.39. The juice was centrifuged and filtered with ease. The analysis of the clarified juice was:—Specific gravity 1.045; acidity 0.54%; "tannin" 0.07%. Concentration was carried out over a two-day period, but details will only be given of three of the samples collected and to which esters were returned.

	Specific Gravity.	Consistency.	Clarity.	Flavour.
1.	1.324	Fluid.	Clear.	Attractive apple character; very acid.
2.	1.337	„	Brilliant.	Good flavour.
3.	1.464	Thick treacle.	„	Strong apple character with only slightly cooked taste.

*Test 13.**Laxton's Superb and Ellison's Orange.*

A bulk of two tons of the above varieties was received on 8.1.40 from Essex. Owing to transport difficulties the fruit arrived in bad condition, being bruised and slightly fermented, and juice was running freely through the sacks on arrival. The greatest difficulty was experienced in pressing the fruit, which was decidedly over-ripe, but the thick, viscous nature of the juice was improved by 20 hour's enzyme action. The juice was concentrated with ease but owing to its low gravity (1.038) a high steam pressure (12 lb. per square inch) did not suffice to produce heavy concentration. A bulk of several gallons of concentrate with a gravity of 1.298 was collected, and the esters for the several tests were combined and distilled in the plant and returned to the concentrates. After twelve months the concentrate was quite fluid, very opaque but perfectly sound and free from fermentation. The flavour was clean and there was a delicate apple character suggestive of a high grade dessert apple.

*Test 16.**Mixed Cull Apples.*

Mixed cull apples from the Long Ashton grader were collected from the following varieties:—Lane's Prince Albert, Bramley's Seedling, Crawley Beauty, Allington Pippin, and Laxton's Superb. The cooking fruit comprised 70% of the blend. The fruit had been exposed to the

severe frosts experienced in February, 1940, but no special difficulties were encountered in milling or expressing the juice (7.2.40). Enzyme treatment was adopted and the filtered juice was used for a series of concentration and ester recovery experiments not discussed here. It was possible to concentrate the juice to a gravity of 1.364, and still maintain perfect fluidity in the concentrate on storage, but a sample with a specific gravity of 1.295 gradually developed a strong fermentation. Previous to the onset of fermentation, however, the concentrated products were characterised by very delightful fruity aromas and flavours. This suggests that fruit of the cooking apple sorts, such as Bramley's Seedling, can provide concentrates with flavour qualities, apart from acidity and astringency, which are equal to those from many dessert apples.

Test 19.

Cox's Orange Pippin.

The last lot of fruit included in the 1939-40 processing programme was composed of Cox culls from an Essex fruit store. The poor condition of the fruit was probably due to prolonged frost damage. It was necessary to wait until the fruit had thawed before milling, and some difficulty was experienced in expressing the juice (19.2.40). On account of the very acid nature of the earlier concentrate, it was decided to reduce the acidity of part of the juice. After enzyme treatment a portion of the juice was treated with sufficient K_2CO_3 to reduce the initial acidity from 0.35% to 0.15%. The control (19a) and treated juices (19b) were filtered and concentrated separately. The chief feature of the experiment was the unpleasant background taste in sample 19b. Even after twelve months there was only a very slight deposit indicating that the potassium salts were being completely retained in solution and giving a saline taste which spoilt the general flavour of the product.

Discussion.

The following general points arise from these experiments :—

- (i) The specific gravity at which fermentation ensued in concentrated juices differed for various varieties, but a minimum of 1.300 can be taken as necessary for certain types of storage and 1.320 for complete safety.
- (ii) The concentration of untreated cooking apple juices invariably led to gelling either in the heating tubes or in the later storage of the product. In one case a firm jelly was produced from a concentrate of specific gravity 1.295.
- (iii) Enzyme action was a sure preventive of gelling, and very high gravity concentrates could be produced by this treatment which maintained complete fluidity over a fourteen month's period of observations.
- (iv) The effects of condition and variety of fruit were not marked in the concentrated products. The effect of condition was only shown in cases where the fruit was appreciably mouldy, in which case a mouldy taint is contributed to the juice which is concentrated with the other constituents.

(b) Recovery of Volatile Constituents.

The concentration of fruit juices by the simple process of boiling entails the loss of the greater part of the characteristic aroma or flavour of the fruit, as the substances responsible are volatile and pass off in the steam. The recovery of this fraction, as carried out in the Kestner Evaporator, permits the return of these volatile substances to the final concentrate with the consequent preservation of the essential character of the fruit.

The proportion of this total volatile fraction present in the juice which can be recovered in this manner is dependent on the temperature and pressure at which the distillation is carried out. The higher the temperature and the lower the pressure, the greater is the total amount of material recovered for a given rate of flow of the juice. The distillate obtained from apple juice consists of a very dilute aqueous solution of ethyl alcohol, acetaldehyde, esters and higher alcohols, acetic acid and higher fatty acids. The actual amounts of such material present in distillates taken off at different temperatures is shown in the accompanying Table I.

TABLE I.
INFLUENCE OF TEMPERATURE ON RECOVERY OF VOLATILE FRACTION.

Temp. °C. Coil Exit.	Vacuum in inches.	Ester liquor as % juice.	Alcohol in distillate g/100 l. juice.	Ester Fraction in distillate g/100 l. juice.
42	27½—27¾	2.0	7.6	0.1
48	27½	1.95	9.0	0.2
52	27½	3.4	9.9	0.57
56	27½	3.6	11.6	0.56

The alcohol, which may be derived, at any rate in part, from slight fermentation of the juice, readily passes over into the distillate by reason of its lower boiling point. The higher alcohols and esters which are mainly responsible for the characteristic aroma of the fruit, and which have boiling points higher than that of water, pass over by steam distillation and the amount recovered is greatly dependent on the temperature of distillation and on the amount of distillate collected. This is illustrated by the figures in the table.

The volume of the volatile fraction obtained in this manner is usually too large to return to the concentrated juice directly, as it would unduly dilute the concentrate. Its volume may, however, be readily reduced by passing it through the plant a second time, using a higher distillation temperature and a slow rate of flow. The volatile constituents may thus be obtained in a much smaller volume of aqueous liquid and without appreciable loss. In some cases (*e.g.* from passion fruit juice) the volatile material may be separated from this concentrated fluid as an oil.

When the ester fraction has been obtained, it is important that it should be added to the concentrated juice without undue delay, or alternatively be stored at a low temperature. Mould growth readily develops in the solutions and decomposes the substances responsible for the aroma. Very concentrated ester fractions may, however, be kept satisfactorily at room temperature, as the constituents, if present in sufficiently high concentration, appear to have an inhibitory action on the organisms.

The quality of the ester fraction obtained from a juice depends very largely on the condition of the original fruit used. The desired freshness of flavour in the final product can therefore only be obtained if the fruit itself is in good condition. Fruit which has become appreciably mouldy or rotten gives an ester fraction which has lost the characteristic aroma of the fruit and is contaminated by a musty odour. Good quality fruit on the other hand gives an ester fraction which retains the essential flavour of the variety to a notable degree. Similarly, fermentation in the juice also modifies the aroma of the ester fraction derived from it and replaces it by one which is in no way characteristic of the actual fruit used. The products of fermentation often mask the esters of the fruit, and the latter themselves may be altered during the process of fermentation.

The examination of the problems associated with the optimum condition for recovery of the volatile constituents, their precise composition and methods of concentration are still the subject of wide investigation and further information may be expected in due course.

(c) Effect of Return of Volatile Fraction on Flavour of Concentrates.

In a series of concentrates taken from the 1939 40 programme the volatile fraction was added to one half of the concentrates leaving the other portion untreated as a control. The immediate effect was invariably that the treated sample possessed a much stronger and fresher aroma than the control. The precise difference in flavour varied with the nature of the esters, which in turn was dependent on the condition of the fruit, but there was no case in which the return of the volatile fraction did not greatly improve the character of the product. In some cases the addition of esters transformed a nondescript product of no characteristic flavour into an unmistakable apple concentrate.

This well defined effect was noticeable for a period of at least eight months after the return of the esters and, although it is difficult to compare taste reactions at wide intervals, there did not appear to be any significant depreciation in the flavour. At the last tasting, however, carried out in January 1941, some fourteen months after the esters had been returned, the effects of the esters had decreased to notable extents. Indeed, various members of the flavour panel did not agree in several cases as to which sample had been treated or which was the control. The flavours of most of the samples were very attractive and as no fermentation whatever had occurred, it must be presumed that various chemical changes had taken place resulting in an alteration in the composition of the flavouring constituents.

B. Apple Treacle.

Reference has already been made above, and in the Annual Report for 1939, to the product which is obtained when apple juice is concentrated beyond the usual limits for normal concentrates. This product has been named "apple treacle"—a name which is suggested both by its physical properties and its high sugar content.

The first samples of apple treacle were obtained more or less accidentally, when evaporation had been continued too far during the processing of juice into concentrate. Examination of these small samples indicated great possibilities for such a product if it could be manufactured on large-scale lines. Tests have therefore been made with this end in view, using the same Kestner pilot-plant as described in the first section of this report.

These tests involved difficulties from the operational point of view that were not associated with ordinary concentrate production, and it seems desirable at this stage to point out that a small pilot-plant is not ideally suited to deal with end-products which have an exceedingly high viscosity. The small cross-section of the evaporator tubes and the narrow apertures of the exits and entries into the final collection vessels inevitably restrict the smooth movement of such liquids through the plant. Also, this tendency to retarded flow is increased where the "treacle" is flowing through exposed and unheated parts of the plant, such as the tubes which lead from the last evaporating effect to the final container, since local cooling takes place and the viscosity increases further. As a result blockage of the plant is liable to occur, and, as in the cases where gelling has taken place in concentrate production, the juice held up behind the blockage is kept too long in contact with the evaporating tubes of the plant, and a condition which rapidly becomes more and more static is set up. The result of over-evaporating treacle is a toffee-like, plastic solid, and when these conditions did occur the tests had to be regarded as failures. All these difficulties, however, were gradually minimised by fitting various control devices, such as a Dewrance constant pressure steam valve, and in any case they are associated solely with the pilot plant and would not occur on commercial scale apparatus.

It must be realised that the small plant in operation at Long Ashton has a maximum intake capacity of 8 gallons an hour, whereas the large evaporators used in industry handle from 150 to 800 gallons an hour. The tubes and apertures in the latter cases are all correspondingly larger, and with so much greater a bulk of liquid in flow there is no opportunity for the troubles of the pilot-plant to appear. Also, the degree of concentration from juices of gravities about 1.050 to final products of about 1.450 is not so near the evaporating limits of the plant.

The obvious way to overcome the difficulty is to ensure both rapid rate of flow and temperatures as high as possible throughout the plant system. But when it is considered that an apple treacle is essentially an apple juice concentrated at least 9–10 times, it is clear that in a small plant a rather slow rate of flow is actually required to achieve such a high concentration even under the most favourable low pressure and high

temperature conditions. Tests which were carried out proved this point, for when the flow was too rapid, although strong concentrates were obtained, the necessary specific gravity for treacles was rarely reached. On the other hand, tests in which the rate of flow was reduced resulted in the sort of difficulties referred to in the preceding paragraph. Samples of apple treacle were obtained, but spasmodically rather than with regularity, and from the all-important point of view of continuous production these tests could not be considered hopeful.

Ultimately the problem was solved by adopting the following procedure :—

- (a) Vacuum concentration of juice to a specific gravity of approximately 1.200.
- (b) Re-evaporation of this concentrate to treacle.

The first stage of the two-fold process was quite simple and could be accomplished with the fastest flow permissible. The second stage, with treacle as the end-product, was also straightforward, the only danger being that of over-concentration. This stage of evaporation involves a reduction of the concentrate to half or a little less than half its volume, and this is a fairly small task even for a small vacuum evaporator. The rate of flow could therefore be kept at a maximum and the high viscosity of the final product thus had much less opportunity to bring about a stoppage.

By this method apple treacle was collected in the final containers just as continuously as ordinary concentrates had previously been obtained.

Although at Long Ashton most of the apple treacle produced in quantity has been obtained by this two-stage evaporation, it is certain that on any industrial evaporator satisfactory production in one stage could be achieved without difficulty. This has been found to be the case in practise, a large treacle-producing evaporator being operated quite smoothly by one skilled workman.

Typical test figures on the Long Ashton plant are as follows :—

- (a) 28 gallons of low gravity Bramley juice (1.038) were converted into concentrate of gravity 1.210. This concentrate yielded $1\frac{1}{2}$ gallons of apple treacle of gravity 1.425, and also 1 gallon of strong concentrate. Conditions for evaporation to treacle stage :—

Rate of flow : 8 gallons per hour.

Vacuum : $27\frac{1}{2}$ inches (barometer $29\frac{1}{2}$ inches).

Steam pressure : 4–5 lbs.

- (b) 100 gallons of same juice as above were converted into 18 gallons of concentrate of gravity 1.210. This concentrate yielded $3\frac{1}{2}$ gallons of apple treacle of gravity 1.485, and 3 gallons of concentrate. Conditions for evaporation to treacle stage :—

Rate of flow : 8 gallons per hour.

Vacuum : 28 inches (barometer 30 inches).

Steam pressure : $4\frac{3}{4}$ lbs.

It will be noted that the theoretical yield of treacle is not reached in any of these tests as calculated roughly from gravity and volume considerations. In tests of this kind the end-loss factor is very high, and the desired product cannot be obtained with the first flow of concentrate through the plant. Both at the start and the end of the run collections of much weaker products than that which is collected during the main bulk of the run are necessary. In industrial practice this end-loss factor would be almost negligible, and in any case the weaker products which appeared at start and finish would be mixed in with the juice for subsequent evaporation.

In all tests carried out to produce treacle at this stage of the work, the juices were initially treated with de-pectinising enzyme in order to remove the pectin. This aspect of the process will be considered more fully in another part of this report, together with the possibility of avoiding the use of de-pectinising enzymes at all. At the time the tests were carried out, however, it was considered from previous experience with ordinary concentrates that, without the prior removal of pectin, gelling would occur—especially where the liquids of high viscosity became cool through loss of flow—and very serious blockage of the plant result.

Moreover, in these tests the juices were partially neutralised in order to avoid too high a concentration of acid in the final treacle. Thus the juice used in the first test above had an original acidity of 0.51% as malic acid; by treatment with a mixture of potassium and calcium carbonates before filtration the acidity was reduced to 0.075%. In the second test the acidity was reduced by similar means from 0.45% to 0.10%. Actually these juices possessed low acidities for the Bramley variety, but this was probably due to the fact that they had been stored for a long time before milling, the tests in question being conducted in March and April.

Partial neutralisation was considered essential since some of the early samples of treacle examined had been acidic in character rather than sweet. This must be the case if a juice of, say, 0.60% acidity is concentrated 10 or 11 times. For this reason, since the utility of apple treacle as a product obtainable from surplus apples seemed to depend largely upon its sugar content, it was decided to aim at an acidity of about 1 to 1.75% in the final product. Actually the acidity of the treacle produced in the second test above was 1.68% as malic acid.

II. A NEW METHOD TO PREVENT GEL FORMATION.

The early studies on the vacuum concentration of apple juice showed the possibility of gel formation both during the concentration process and on storage, and, with the pectin, sugar and acid contents of the juice increasing as water is removed, suitable conditions for gel formation are obviously liable to develop. Even when gelling occurs only after the warm concentrate has been removed from the plant and stored, it is not a desirable development, since when jelly products are required their production must take place under controlled conditions.

This difficulty was easily overcome by making use of the now well-known de-pectinising enzymes referred to in the first section of this report, which destroy the pectin in the juices before evaporation and make gel formation under any conditions impossible. In no Long Ashton experiment has a de-pectinised juice ever subsequently gelled either during the process of evaporation or later, and jellies have been produced from the resulting product only by adding pectin. In addition to this function, the de-pectinisation process has the added virtue of producing a much better and easier clarification of the juice. De-pectinised concentrates were very markedly clearer than those made from untreated juice.

Unfortunately the necessary enzyme is not home-produced and, with the development of war, large quantities have become more and more difficult to obtain. It was hoped that production of a suitable enzyme on a commercial scale would be commenced in this country, but so far, despite efforts on the part of this station to encourage likely manufacturers, this has not been the case. Thus, should an apple surplus similar to that of 1939 again arise and should food manufacturers undertake the large-scale conversion of that surplus into concentrates and treacle, the necessary supplies of de-pectinising enzyme might well not be available. It seemed vital, therefore, to find some other method by which non-gelling could be ensured.

Attention was directed to the conditions of the formation of the sugar-acid-pectin gel. The results of such workers in this field as Barker (1), Tarr (2) and Hinton (3) have established the fact that the strength of these gels varies most sensitively with the amount of acid present—or more accurately with the pH. For most fruit pectins the sugar gel of maximum strength is formed at a pH of between 3.10 and 3.20. Since the pH values for most apple juices are near this range, the tendency for gel formation when the natural sugars are concentrated is easy to understand. However, since the strength of gel lessens appreciably as the pH moves below or above this optimum point, chemical alteration of the pH of apple juice before concentration suggested itself as a means of preventing gel formation.

It was obvious that a reduction of the pH would present other problems, since the eventual product would be so strongly acidic that its value as a food product would be decreased. On the other hand, increasing the pH would yield a product of lower acidity and consequently of enhanced sweetening value. As indicated previously the partial neutralisation of apple juices before concentration had been carried out in other experiments in order to obtain a low-acid concentrate or treacle, but in these cases de-pectinisation had always taken place as well and thus there had been no opportunity to observe the specific effect of pH alteration on the tendency to gel.

The following series of experiments was therefore conducted. Samples of apple juice were taken and their pH values increased by the addition of varying amounts of calcium carbonate. The juices were then concentrated by evaporation in a thick preserving pan over gentle heat, and

small samples of the juice taken off as the concentration progressed. These samples were left to cool undisturbed and their condition later examined. The results are given in Table II.

TABLE II.
EFFECT OF VARIATION IN pH ON GELLING OF APPLE JUICE CONCENTRATES OF VARYING STRENGTHS.

Juice.	Soluble Solids %.	Condition of Concentrate.
A. Untreated. Acidity = 0.77% pH = 3.08	56	Liquid.
	58	"
	66	Gel.
	70	Strong gel.
	73	Sticky gel.
	82	" "
	85	" "
	86	" "
B. Treated with depectinising enzyme. Acidity = 0.77% pH = 3.08	60	Liquid.
	66	"
	73	Very viscous liquid.
	77	Thin treacle.
	85	Treacle.
	89	Thick treacle.
C. Treated with CaCO_3 . Acidity = 0.08% pH = 5.99	56	Liquid.
	65	"
	71	"
	81	Treacle.
	82	"
	89	Thick treacle.
	92	Sticky plastic solid.
D. Treated with CaCO_3 . pH = 4.80	66	Liquid.
	68	"
	71	"
	75	Thin treacle.
	81	Treacle.
	83	Thick treacle.
	87	" "
	90	Sticky plastic solid.
E. Treated with CaCO_3 . Acidity = 0.22% pH = 4.43	60	Liquid.
	65	"
	67	"
	72	Thin treacle.
	80	Treacle.

By comparison of C, D and E with the two different controls, A and B, it is clear that the respective changes in pH have prevented gel formation with an efficiency equal to that of the enzyme action, and have allowed the production of liquid concentrates or treacles at the requisite contents of soluble solids. The exceptional strengths of the gels formed in sample A indicate that the juice taken for the experiment was sufficiently pectinous to give strong gels under normal conditions.

This method of treatment does not entail any additional processing as almost all schemes to produce treacle or concentrate will probably involve a partial or even complete neutralisation of the initial juice.

The only cases where this method cannot be used will be those in which concentrates are being produced wholly or partly for their acidic quality, such as for use in the mineral water or fruit squash industries. It seems that for these purposes the enzyme method must still be employed unless a low soluble solids concentrate is aimed at.

TABLE III.
ANALYSES OF APPLE TREACLES.

Method of production, etc.	Specific Gravity of Treacle.	Total % Soluble Solids.	Acidity % as malic acid.	Sugars %		Ca pectate %
				Invert.	Sucrose.	
A. Vacuum evaporation of Bramley's Seedling Juice. De-pectinised and partly neutralised with K_2CO_3 and $CaCO_3$	1.485	89.9	1.68	64.1	1.9	—
B. (i) Vacuum evaporation of Kentish cull apple juice. De-pectinised and partly neutralised with $CaCO_3$ (ii)	1.389	77.4	1.3	49.0	14.0	—
	1.422	87.6	2.25	48.5	17.6	—
C. Vacuum evaporation of Bramley's Seedling apple juice. De-pectinised and partly neutralised with $CaCO_3$	1.377	80.5	0.65	41.3	11.9	0.0

III. THE UTILISATION OF APPLE CONCENTRATE AND TREACLE.

The publication of a preliminary report on the production of apple treacle resulted in a large number of enquiries regarding its use in a variety of food products. A series of laboratory experiments were carried out at Long Ashton, and a comprehensive and extremely valuable series of recipes were worked out by the Research Department of the Metal Box Company, using apple products made at Long Ashton. This latter series includes recipes for puddings and hot sweets, sago and apple charlotte, treacle tart, apple sago mould, fruit cake and apple treacle cake, and, finally, apple and apple barley drinks. Concentrated apple juice products made in 1939 and 1940 have already been in great demand from the confectionery, mineral water and food industries and the supplies have been hopelessly inadequate to meet their combined requirements. A wide variety of recipes has also been received from private members of the Research Station or interested organisations, all of which tend to show that the product had infinite possibilities in cooking or baking processes. These recipes are not given here, but the results of two series of small scale experiments on the use of apple treacle as a substitute for sugar in jam-making and as the base for a concentrated apple jelly will now be discussed.

A. Apple Treacle in Jam Making.

The use of apple treacle as a substitute for cane sugar in jams has been briefly investigated in view of the great public demand for supplies of sugar for jam-making in the summer of 1940.

The first experiments were made with early gooseberries of the 1940 season. The apple treacle used had the following analysis:—Invert sugar, 64.1%; sucrose, 1.9%; acidity, 1.68% as malic acid.

TABLE IV.

GOOSEBERRY JAMS USING APPLE TREACLE.

(The soluble solids contents of all these jams were within the range of 68.5–70%).

	Wt. of fruit.	Wt. of sugar.	Wt. of treacle.	* % of sugar replaced.	Set.	Remarks.
A. Control	1 lb.	1 lb.	Nil	Nil	Firm.	Rather thin flavour.
B.	1 lb.	10 oz.	8½ oz.	37.5	Firm.	Pleasant flavour, fuller than "A."
C.	1 lb.	8 oz.	11½ oz.	50.0	Firm after longer boiling than "A"	Flavour good but slightly inferior to "B."
D.	1 lb.	6 oz.	14½ oz.	62.5	Sticky set.	Treacle flavour too predominant.

* This column expresses the percentage of sugar replaced by apple treacle, not the percentage of treacle in the final jam.

A number of tasters were invited to sample these jams, and samples B and C were favourably commended. Indeed, sample B was almost unanimously preferred to the control jam A, the opinion being generally expressed that it possessed a much fuller and richer flavour. In sample C the greater amount of treacle made itself slightly noticeable on the palate, the gooseberry flavour being correspondingly less evident; but this effect was not strong and the jam was quite pleasant. Sample D was as unsatisfactory in flavour as it was in set, the treacle flavour being too conspicuous.

Jams as satisfactory as B and C were made by the same recipes with plums, blackberries and black currants, though in these cases preserved fruit (bottled or sulphited) had to be used, since the investigation was carried out in the early summer. In the case of black currant jam, it was found that treacle replacement up to 50% (*i.e.* recipe C) did not intrude at all upon the true character of the jam, this being undoubtedly due to the powerful flavour of black currants. The plum jams retained their characteristic flavours when recipe B was followed.

The effect upon colour is naturally to darken the jam, the degree of darkening being proportional to the treacle content. In the case of the gooseberry jams, the control jam was green, B was a rich greenish-brown, rather like jam made from very ripe gooseberries, C was brown, and jam D dark brown. The changes in colour were not nearly so marked in the cases of the jams made from red fruit.

Samples of these jams that had been commended by the tasting panel were taken to the Ministry of Food and were again favourably received.

It is felt that sugar substitution by apple treacle according to recipe B produces a jam that has in no degree lost its true character ; and that greater substitution as in recipe C, though it saves more cane sugar, introduces a certain deterioration in flavour except in cases where the fruit used is very powerful in flavour. Substitution to the extent of recipe D cannot be advised.

There are two points which should be made clear in connection with "treacle jams."

Firstly, apple treacle cannot be expected to replace its own weight of cane sugar. The treacle used in these experiments had a total sugar content of 71%, and therefore for each ounce of sugar replaced $\frac{1}{4}$ ounce of treacle were needed.

Secondly, in making these jams the boiling process must be adjusted to effect the removal of moisture from the treacle as well as from the fruit. The treacle was added at the commencement of heating and boiled with the fruit, the cane sugar being added at the latest possible time. This is an important point since there is a large content of invert sugars in the treacle, and it was desirable to ensure that too much of the cane sugar should not be inverted.

It is possible that this use of apple treacle might be more suited to the commercial manufacture of jams where technical control is more rigid than in ordinary domestic jam making. But these Long Ashton investigations have been purely exploratory, and intended merely to indicate certain ways in which apple treacle can possibly be used.

B. Apple Concentrate and Treacle in Jelly Making.

The production of apple jellies of a new kind from concentrates without the use of sugar has been indicated in the Long Ashton Annual Report for 1939. During the past year, with the vacuum evaporator at Long Ashton in constant operation during the 1939-40 apple season, a closer study of this matter has been possible.

No particular difficulty has been encountered in obtaining these jellies. Provided that the concentrate taken contains a sufficiency of soluble solids and the correct hydrogen ion concentration, the addition of pectin will, after warming and subsequent cooling, yield quite clear and firm jellies. The necessity for adding pectin, which has been discussed before, arises from the fact that the original pectin in the juice must be destroyed by enzyme action in order to produce the concentrate. For this work the source of pectin has been a commercial solution of apple pectin containing about 5% pectin.

A thick concentrate of gravity 1.398 made from Cox's Orange Pippin apples was diluted with water to produce samples with descending

gravities. Pectin was then added and the figures below show the results obtained :—

Specific gravity of concentrate.	Amount of pectin extract added.	Result.
1.398	10%	Very rigid jelly.
1.382	10%	Firm jelly.
1.370	10%	Firm jelly.
1.360	10%	Much weaker jelly.
1.350	10%	Too weak, state of semi-gel.

It is interesting to note that the mixture of 10% pectin extract with the 1.370 concentrate produced before gelling a liquid with gravity of 1.337, which corresponds to a soluble solids content between 68 and 69%. This is very close to the figure of 68.5% soluble solids, which is considered to be the minimum figure for satisfactory jam and jelly making when ordinary cane sugar is used.

Jellies were obtained by using lesser amounts of the pectin extract, quite strong jellies being obtained with 5% pectin extract and a concentrate of gravity of 1.376. But, in general, the optimum figure for the pectin extract addition was round about 10%.

In cases where concentrates had lower gravities than 1.370 these gravities were raised by the addition of cane sugar to the desired figure, and again jellies were formed without difficulty. A large batch of jelly was made by blending :—

$\frac{1}{2}$ Gallon of concentrate at 1.397.
 $\frac{3}{4}$ " " " " 1.330.
 $\frac{3}{4}$ " " " " 1.340.
 3 lbs. cane sugar.
 $3\frac{1}{4}$ " of pectin extract.

The whole liquid—of gravity 1.376—thus produced was warmed to about 150°F. and then allowed to cool in jars. About 32 lb. of jelly was made.

Samples of the jelly were sent to numerous interested persons in all parts of the country. The quality and unusually pronounced fruit flavour of this jelly was almost unanimously praised. The large-scale production of an apple jelly of this type was considered by several food manufacturers, but doubts as to the expectation of any surplus of apples in the 1940 crop operated against a definite decision. At the moment, so far as is known, this type of jelly has not yet been produced except at Long Ashton, and there only in experimental quantities.

The question of using apple treacle as a source of jelly depends upon the acidity left in the treacle after the neutralisation. Clearly if the pH is not considerably less than 4.0 and preferably round about 3.0 the addition of pectin will not produce a gel. The dilution of the treacle

to form concentrates for jelly making would seem to be a retrograde step. On the other hand the jellies made from treacles are very concentrated products and set rather too firmly even with only small additions of pectin. It is felt that apple jelly is best produced from concentrates of normal strength rather than from treacles.

It is a moot point whether jellies from concentrates below 1.370 with added sugar or jellies from concentrates of 1.370 without added sugar are better. It is entirely a matter of taste, the clarity and set of the two types being equally satisfactory.

SUMMARY.

1. The conversion of a wide variety of apple juices into concentrates is described, and the treatment for removal of pectin is discussed.

2. Details of the methods employed to remove the volatile fraction continuously during concentration are given as well as the composition and effect of the returning of the aromatic fraction to the concentrate.

3. The production of apple treacle has been examined in a comprehensive manner. Using a pilot plant, a two-fold evaporation was preferred, the first stage taking the juice to a gravity of 1.200, and the second to the final treacle with gravity of 1.400 or higher.

4. In view of the extreme difficulty in obtaining pectin-decomposing enzymes an alternative method for preventing gel formation in thick treacles is desirable. It was found that a controlled neutralisation of the juice raised the pH to a figure at which gel formation was impossible. By this means very concentrated treacles could be produced without the use of enzymes.

5. For treacle production from very acid apples it is desirable to neutralise practically the whole of the acidity in the juice.

6. Analyses of treacles are given.

7. Some domestic and commercial uses for apple treacle are indicated, including its use as a partial substitute for sugar in jam, as a base for concentrated apple jelly, and for a number of cooking and baking purposes.

Acknowledgment.

The authors wish to express their cordial appreciation of the valuable help afforded by Miss M. E. Kieser in the analytical work connected with these investigations.

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CONCENTRATED PLUM PRODUCTS.

THE PRODUCTION OF CONCENTRATED JUICES, PUREES AND POWDERS.

By VERNON L. S. CHARLEY, D. P. HOPKINS, and A. POLLARD.

The publications of this Research Station contain no previous references to satisfactory new methods of converting large quantities of surplus plums into stable foodstuffs, but from time to time attempts to solve this problem have been made. The jam-making and canning processes were, of course, not included in the scope of the investigations as these subjects are dealt with elsewhere. However, it appeared that there was a limit to the amount of fruit that could be utilised in these processes and alternatives were examined in order to provide as many outlets as possible for surpluses of this fruit. The problem was complicated by the very short period during which the fresh plums were available, and it was desired to avoid the SO_2 pulping process if possible in order to reduce the necessary processing to the minimum on account of cost. Early attempts had included the preparation of plum juices, which were difficult to produce both on account of the extraction of the juice and the initial and permanent clarification of the expressed juice. Wines were also prepared but the characters of the products were harsh and maturing processes over a period of 3 years failed to improve the flavours. Some experiments which were carried out for the Metal Box Company resulted in the production of very interesting and attractive sweetened products to which the name of "plum nectar" was given. The product, was, in effect, a somewhat diluted plum puree sweetened to taste and canned. The processes involved were developed to a stage in which commercial production appeared possible, but the sugar rationing scheme occasioned by the War has prevented any commercial development to date.

The problem was raised again in an official form in June, 1940, when the Research Station was approached by the Ministries of Agriculture and Food to discuss what new processes could be developed which would enable fresh plums to be satisfactorily converted into stable forms of food during the actual plum season. In view of the presence of the Kestner vacuum evaporator and the necessary complementary equipment at the Station it was decided to examine the possibilities of producing concentrated juices. This work was commenced but many obstacles were encountered, some of which were only overcome as a result of the work on apple juice concentrates which is described in the previous contribution in this Report (page 97).

Attention was next paid to the production of a puree which might have commercial possibilities as a substitute for other materials which

were previously imported from enemy or enemy-occupied countries. The purees obtained are of great interest to the food trade and it is anticipated that some production will commence early in 1941.

As representing the upper limit of concentration, powders were produced from the plum puree using a Kestner patent spray drier. These products have gained very considerable publicity and would appear to represent a significant contribution to the solution of the problem of surplus plums. Commercial production was commenced in January 1941.

The attractive nature of the puree and powder processing is largely due to the fact that no expression of the juice is needed and thus one of the most difficult operations is avoided. A further feature of these processing schemes is that very large quantities of plums can be dealt with during the plum season, thus avoiding any possible complications due to the presence of SO_2 .

Experimental.

1. Concentrated Plum Juice.

Plum juice is a much more difficult product to obtain than apple juice. The fruit is highly pectinous and "slimey." When built in cheeses as for the normal apple pressing procedure, the fruit tissue, when under pressure, is often forced through the cloths. Even when these troubles are overcome there is the further problem of the stones, for when pressure has reduced the thickness of the cloths the volume of stones present is liable to interfere with and greatly reduce the application of greater pressure. It will therefore be understood that the juice extraction problem occupied considerable attention before the real work of concentration could be approached.

(a) Concentrates from Plums Stored in SO_2 .

The first concentration experiments were conducted in June, 1940, and since fresh plums were unobtainable at that time, 1939 season fruit, stored whole in sulphur dioxide solution, had to be used. During storage, juice had inevitably passed from the fruit into the surrounding liquid, and *vice versa*; consequently any juice obtained from the stored plums was diluted with water to an extent not known. Moreover the plums had not been preserved at Long Ashton and no reliable accurate figures were available as to the amounts of water originally used.

The liquor in the casks could be freed from most of the SO_2 by boiling vigorously for ten minutes. It was then treated with 0.1% of de-pectinising enzyme in the same manner as for apple juice. The fruit was boiled for about fifteen minutes to remove SO_2 . A weight of fruit equivalent to the volume of juice was always taken, having regard to the total amounts of fruit and liquid present in each cask. Since preliminary qualitative tests had indicated the difficulties of pressing plums, the boiled fruit was treated with de-pectinising enzyme, the enzyme being mixed in by powerful agitation; the weight of enzyme used was 0.1%

of the anticipated yield of 130 gallons per ton. It was found that the use of enzyme on the fruit before pressing greatly checked the tendency of the cheeses to slip, though the tissue was still very liable to escape through the press-cloths. Moreover, the pomace did not fall away from the cloths cleanly as with apple pomace, but had to be scraped off - a factor that increased the labour of the operation though it did not affect the efficiency of juice extraction. The two juices - that from the cask liquor and that from the pressing of the pulp - were mixed, giving a very cloudy juice containing more tissue than would be the case with apples. Centrifuging at a slow rate removed the tissue, leaving a reasonably clear juice, though much more opalescent than de-pectinised apple juices.

The total yield from 75 lb. of Purple Egg Plums (including the juice from the cask liquor) was 15.5 gallons of specific gravity 1.039. This juice was concentrated in the vacuum plant without difficulty, giving a yield of 1 gallon of gravity 1.290 and 1 gallon at 1.280. The concentrate was clearer than might have been expected having regard to the opalescence of the juice, and it was more viscous than an apple concentrate of similar gravity. The acidity, as malic acid, was 10.8%; the sugar content was 38.0% as invert sugar with no sucrose present. The absence of any sucrose might be due to the complete inversion of the sugars during the time of storage.

The esters were much less fragrant than apple esters, and did not suggest the fruit character in the pronounced degree that has been noted with the apple. There was, however, a very strong snell of "oil of almonds," probably due to the fracture of stones during the pressing operations. In any case the long storage in SO_2 and the boiling given to the fruit are not conditions which assist in the retention of the true esters. There has unfortunately been no opportunity of examining this aspect of plum juice concentration in any detail.

A similar experiment with Yellow Egg plum pulp was not so satisfactory. Despite de-pectinisation of the fruit the pressing was difficult and double cloths had to be employed to re-press the escaped tissue. After centrifuging, the juice was still very cloudy.

On the other hand, some Pond's Seedling plums stored whole in SO_2 were pressed with ease, even to the extent that the pomace fell cleanly from the press cloths. It was conjectured that this pressing problem might well be connected with the state of ripeness of the plums when originally put into storage; it was known that this particular sample had been sulphited in a state of perfect maturity, whereas the other samples had been in a mixed condition of ripeness when put down.

In this case, 206 lb. of fruit yielded 20 gallons of juice with a gravity of 1.046 and acidity, as malic acid, 1.57%. Before clarification, this juice was partially neutralised, following the lines of the early Long Ashton work on strongly acid apple juices. 1.9 lb. of potassium carbonate were added to reduce the acidity to about 0.5%. The juice was concentrated without difficulty, and concentrates were obtained with gravities 1.312, 1.300 and 1.275.

The analysis of two of these concentrates from stored plums provided the following information:—

	<i>Yellow Egg Concentrate.</i>	<i>Pond's Seedling Concentrate</i> (acidity reduced).
Specific gravity	.. 1.278	1.305
Acidity (malic acid)	.. 9.33	4.06%
Invert sugar	.. 34.1	31.5%
Sucrose	.. 0.0%	0.3%
Calcium pectate	.. traces only.	traces only.

(b) *Concentrates from Fresh Plums.*

The next experiments were carried out in the plum season on freshly picked fruit, and a new difficulty appeared at once.

To soften the plums for enzyme treatment and subsequent pressing, the fruit was steamed with a little added water (about 1 gallon to 1 cwt. of fruit). This process was not vigorous, being conducted only long enough to soften and break up the fruit. On cooling, when the temperature had fallen to 130° Fahr., the calculated amount of enzyme was added. During the 24 hours necessary for this enzyme action, however, an unexpectedly rapid fermentation also took place. In such warm weather as was experienced in August, 1940, the rate of cooling was very slow, particularly when the temperature for optimum yeast activity was reached. On pressing the juice it was found to have an alcohol percentage of 2.17 and a gravity of only 1.019.

In a second attempt with fresh Purple Pershore plums fermentation again ensued even though the time for enzyme action was reduced. The fermentation was proceeding rapidly throughout the pressing operations and was not checked until the juice had been centrifuged. On attempting to concentrate this juice, gelling occurred whenever gravities of 1.280 to 1.300 were reached, which suggests that the reduced time for enzyme action had resulted in a less satisfactory removal of pectin.

These experiences were valuable inasmuch as they indicated that the preliminary heat treatment to soften fresh plums was unwise, at any rate in warm weather and in the height of the fruit harvest when the atmosphere of fruit-handling factories is certain to be charged with yeast activity. A cold process was therefore examined.

The fruit was milled cold with the concave of the grater mill set sufficiently widely to obviate much fracture of stones. The milled fruit was then left for 36 hours with the de-pectinising enzyme. Despite the same warm weather conditions fermentation did not occur, and the action of the enzyme was quite satisfactory. As with most soft fruit, the tissue mainly collected into bulky top and bottom layers leaving a large volume of juice in between. From 3½ cwt. of Yellow Egg plums 15 gallons of juice were decanted from the containing vessel, and another 12½ gallons were obtained by pressing the remaining tissue. This

operation, although less straightforward than apple pressing, was reasonably satisfactory. The concentration of this juice presented no problems. This concentrate had the following analysis:—

Specific gravity	..	..	..	..	1.276
Acidity (malic acid)	..	..	..	..	6.77%
Invert sugar	..	..	..	..	30.0%
Sucrose	..	..	..	..	7.4%
Calcium pectate	..	..	..	..	traces only.

Before leaving the problem of plum juice extraction from fresh plums some figures for yield of juice from given weights of fruit can be given. The average yield from batches of $3\frac{1}{2}$ cwt. was 26 to 28 gallons, thus indicating a yield per ton of approximately 150 gallons. This figure might be improved upon in larger-scale operations, since in the above experiments only a small press could be used. The use of large hydraulic presses, however, will involve the problem of avoiding stone fracture if the full pressure is to be exerted. Again, it may possibly be an advantage to remove the stones before pressing and obtain a homogeneous product to place in the cloths.

2. Plum Puree.

In view of the difficulties described above in expressing the juice from plums attention was next given to the possibility of utilising the whole of the plum with the exception of the stone, and a form of puree was made from several well-known varieties. The jam-making process for preserving plums in SO_2 usually consists in stewing the fresh fruit in steam jacketed jam pans until the plums are almost completely disintegrated. The pulp is then either preserved in that form or it is first passed through a coarse sieve to remove the stones. This material, however, is already produced on a very large scale and the technique of production is well-known. In the Long Ashton work, a material of this type was passed through a Gardner disintegrator to give a product with a much finer texture which was then boiled down to a little over half its volume. By this means, finely divided purees have been produced in large batches at Long Ashton. The total solids have varied from 16-20%, the soluble solids generally being about 1% less. Samples of these purees were taken in August 1940 and bottled and pasteurised at once. Perfect freedom from fermentation, mould growth or obvious decomposition has been achieved by this method of storage over an 8-month period. The problems involved in bulk storage and canning are now being examined.

One of the major repercussions of the war on the food industry has been the shortage of containers, especially of wooden barrels. Consequently, it was necessary to determine the maximum possible concentration that could be carried out on the plum material. A charge of 100 lb. of plum pulp was heated in a 30 gallon jam pan. Evaporation proceeded at a rapid rate until the normal puree concentration had been attained but beyond this the steam pressure had to be raised to 20 lb. per square inch to effect any further reduction in volume. Much burning took place around the sides of the pan, and this formed a layer of hard non-conducting

material which further reduced the effect of the heat. An analogous batch of the same plum material was treated with 0.2% of enzyme and boiled down after 24 hours. Much higher concentrations than before were easily obtainable; boiling proceeded freely at steam pressures of 10—12 lb. per sq. in., and there was a complete absence of burning round the pan.

The sauce and pickle industry has shown great interest in these plum purees but insufficient quantities of plums have been available to meet the demand either for the puree or powder (see later).

The details of analysis of the plum purees are given in Table I.

TABLE I.
ANALYSES OF EXPERIMENTAL FRUIT PUREES AND POWDERS.
(June—October, 1940).

	(1) Yellow Egg Plum	(2) Yellow Egg Plum	(3) Yellow Egg Plum	(4) Purple Pershore Plum	(5) Purple Pershore Plum	(6) Victoria Plum
Material used	1939 pulp with SO ₂	Same as (1)	1940 crop fresh fruit,	1940 crop fresh fruit,	As for (4).	1940 crop fresh fruit,
State of ripeness of fruit	Slightly immature	Same as (1)	Fully ripe	Very ripe		Very ripe
PUREES.						
Method of making puree	Stew ; sieve ; G* ; boil down	As for (1) but de- pectin- ised	As for (1)	As for (1) ; very thick	As for (4)	As for (1)
Preservation of puree for transport to drier	Nil	Nil	Nil	Nil	—	2,000 ppm SO ₂
Analysis of puree—						
Total solids %	16.4	20.1	16.8	21.0	—	15.0
Soluble solids %	15.4	18.2	16.5	19.2	—	—
Invert sugar %	7.6	10.0	6.9	10.7	—	7.7
Sucrose %	0.2	0.0	0.2	0.2	—	0.0
" Tannin " %	0.28	0.30	0.26	0.34	—	—
Malic acid %	2.42	2.82	2.52	3.44	—	1.83
Total pectin % (as calcium pectate)	1.09	0.0	1.03	1.11	—	1.06
POWDERS—						
Analysis of powder.				Drying Test 1	Drying Test 2†	
Moisture %	13.5	—	10.79	10.40	9.52	7.36
Invert sugar %	41.6	—	36.5	41.9	39.6	38.9
Sucrose %	0.0	—	0.43	0.57	0.57	0.0
Acidity (malic acid) %	14.4	—	13.5	13.0	12.9	10.15
Ash %	3.98	—	—	—	—	—
Total pectin % (as calcium pectate)	7.10	—	6.10	5.78	5.94	5.79
Protein % (N ₂ × 6.25)	5.49	—	4.39	2.35	2.42	2.27
SO ₂ (p.p.m.)	101	—	—	—	—	64
Ease of removal of powder from spray drying chamber	Easy	Impossible to dry	Easy	Difficult	Difficult	Easy
Nature of powder	Dry ; slight superficial caking after 6 months' storage		Very fine and dry after 6 months' storage	Dry powder ; slight caking	Very good powder ; less caking than in Test 1	Very fine, dry powder

* G indicates passage of puree through a Gardner disintegrator.

† Apple pectin added to puree for drying test.

3. Plum Powder.

(a) Semi-commercial Tests.

An opportunity was afforded the Long Ashton Station to make use of a Kestner patent spray drier installed in a London works and a series of

purees, chiefly made from plums, but also including apple and blackberry, were sent to London for drying. In some cases when fresh fruit was used, a heavy dose of SO_2 was added to the puree to preserve it during the protracted journey to the spray drier. The tests were carried out on batches of 12 gallons of puree with soluble solids contents varying from 16—20%. The tests were obviously not designed to throw light on the fundamental considerations underlying the spray drying of such fruit purees and no precise information of a significant nature has, in fact, been obtained. The tests, however, indicated the possibility of preparing satisfactory powdered products from plums, apples and blackberries, and subsequent work has shown that such prepared powders can be used in a variety of foodstuffs. It is unnecessary to emphasize the advantage possessed by fruit powders in the matter of storage accommodation or stability during storage.

The following observations arise from a consideration of the data on the powders in Table I.

(i) *Moisture*. The figures are much higher than would normally be the case in commercial practice but the uncertain conditions under which the tests were done were responsible for this. The samples were stored in large 12 lb. tins with tightly fitting lids, but these were opened daily over a period of many weeks. During this period only a very slight absorption of moisture has taken place but the few lumps which have formed on the surface of most of the powders can be easily crumpled by gentle pressure of the fingers and in no single case has this very considerable contact with air caused any definite stickiness in the product.

(ii) *Organic Constituents*. The data for sugars, acids, pectins and proteins suggest that, as far as these constituents are concerned, the spray-dried product preserves the full nutritional value of the puree and thus of the fruit. The high pectin content is also indicated by the nature of the powder after it has been wetted with cold water. The original consistency of the puree returns and the fineness of texture of the re-constituted puree is considerably increased, presumably due to the action of the particular method of spray formation in the drier. The pectin retains its full setting power and firm jellies can be made merely by addition of sugar and water.

(iii) *Sulphur Dioxide*. The persistence of the SO_2 right through to the powdered product was contrary to expectation. It suggests that the preservative is in some comparatively stable form of chemical combination with certain constituents of the powder. It should be understood, however, that the addition of the SO_2 to the concentrated puree was necessary only to maintain stability during the railway journey (which was very uncertain in length) and that in normal procedure the puree would be spray dried directly it was produced. The SO_2 introduced in the ordinary preservation of the plums is efficiently removed by the boiling down process and very little SO_2 remains in the concentrated puree.

(iv) *Ease of Drying*. All the purees except the depectinised Yellow Egg sample dried perfectly easily as far as powder formation is concerned,

but the Purple Pershore samples offered some difficulty in removing the powder from the drying chamber. Whereas the powder should fall freely and form a loose deposit which removes itself continuously from the drying chamber the Purple Pershore powder had to be removed by hand. Apparently there was a slight tendency to "cake" and this affected the manipulation of the powder. The puree from which the pectin had been completely removed would not dry at all, the end products being long strips of toffee-like material.

(v) *General.* Apart from the observation made in (iv) above, concerning the effect of depectinisation on spray-drying procedure, no definite information has been obtained to suggest any correlation between certain chemical constituents and the behaviour of the puree on being dried. The analyses for 8 different purees vary to a considerable extent and yet good powders were obtained from all the batches.

(b) *Commercial Tests.*

Through the courtesy of a Somerset firm possessing a very large Kestner patent spray drier, some commercial tests on drying plum puree were carried out on two ton batches of puree. The concentrated puree provided a heavy load for the pumps and it was eventually found essential to use a puree in an unconcentrated form and to include the Gardner disintegrating mill as an integral part of the procedure. The powder did not discharge freely for some time after the commencement of drying but in a run of 3 hours' duration about one-third of the total quantity of powder was freely discharged, and the rest was easily removed when the plant was cool. During the operation of the plant the powder was obtained in spongy lumps about the size of walnuts but after 1 minute's exposure to the air the lumps became hard and could be ground to a fine powder through any ordinary type of mill. This powder has shown satisfactory analytical, flavour and storage properties.

4. Uses for Plum Powder.

The commercial utilisation of fruit powders is only now being examined but the advantages offered by the saving of bulk storage space appear to be so great that the ideal method of storage of fruit over long periods, up to 2 years, would be as a powder. The product can be converted into a puree of any desired concentration by the addition of the required amount of water, whilst the pectin content is ample to form a firm jelly when the powder is diluted with water and sweetened with sugar. This latter factor may possibly be developed into a method for the domestic or commercial manufacture of jam all through the year from powder instead of pulp. It is not suggested that the powder has any advantages over pulp for jam-making, but the storage of large quantities of plums or other fruits which occur in gluts could be satisfactorily undertaken by the production of dry powders, when the necessary storage space was not available for the more bulky pulp.

Although the work at Long Ashton has been primarily directed towards a study of the production of these powders, a short and exploratory consideration of their uses in jam-making has been possible.

One method of making a form of stoneless plum jam from powder is quite simple and the housewife would find it easier to make plum jams from powders than from fresh fruit. The degree of concentration represented by the powder must be known so that the requisite amount of water can be added so as to convert the powder to its original state as a puree. The addition of sugar followed by the usual boiling process will produce a well-set jam. Pectin addition is quite unnecessary as the jellying power of the fruit seems to be in no way damaged by the spray-drying treatment. Tests with gelatin gels, using plum powders purely as a source of pectin, have shown that very strong gels are formed. A sucrose gel containing 10% of plum powder had a strength of 100 units, compared with 38 units for a similar gel made with 30% of a standard apple pectin extract.

The texture of the jams is naturally not entirely similar to that of jams made from fresh fruit since the entire tissue and flesh of the plums has been finely disintegrated in the preparation of the intermediate puree and the sub-division has become even finer in the formation of the powder and its subsequent handling. The texture of the jam is therefore very smooth. With proper standardisation of plum powders the amount of water to be added could be carefully regulated so that the boiling operation could be reduced to a very few minutes.

The possibilities offered in this method of making jams would seem to deserve consideration by the food trade. A powder could be sold to the public from which plum jam can be made at any time in the year. Less than three ounces of this powder would suffice to make about two pounds of jam. In war-time or even under more normal conditions there should be a popular demand for such a product. Under present conditions two potential advantages are outstanding—housewives could make small quantities of jam as and when they had sugar surpluses available and these jams could be, if desired, of low sugar content for consumption within a few weeks of making.

The use of this powder for jams is, of course, not confined to domestic makers. In this connection one firm of preserve manufacturers has already prepared an attractive range of products from samples supplied by Long Ashton. Finally, it may be stated that similar jams and jellies have been made from apple and blackberry powders.

Summary.

1. The production of concentrated juices from fresh plums and from fruit preserved in SO_2 is discussed in detail. The chief difficulties associated with expression of the juice are described and methods are given which have allowed satisfactory processing to be carried out. The liability of the plum material to violent fermentation necessitates the shortening of the period of enzyme action to remove pectin; in some cases it was impossible to concentrate to a gravity above 1.280 without gel formation.

2. Attractive purees have been produced by steaming the plums and passing the cooked material through a seeding machine, followed by a Gardner disintegrator. The fine puree is boiled down to about half volume, *i.e.* 16-20% total solids. The purees can be used as alternatives to other products which are only produced abroad.

3. The concentrated forms of purees have been successfully reduced to fine powders by a semi-commercial Kestner spray drier. Commercial production has also been commenced and very fine powders with valuable food properties have been produced. The pectin retains its setting power in the powder and attractive jams can be made merely by the addition of sugar to the puree reconstituted to the correct strength by diluting the powder in water.

Acknowledgment.

The authors wish to express their appreciation of the help afforded by Miss M. E. Kieser in the analytical section of the work.

A NOTE ON THE PRODUCTION OF BLACK CURRANT JUICE AND ITS SUITABILITY AS A SOURCE OF VITAMIN C.

By VERNON L. S. CHARLEY and V. E. SILLS.

The Annual Reports of this Station for 1936 and 1937 contained full accounts of the commercial scale processing of black currant syrup that had been based on the work of the senior author of this note. Since that time, the production of the syrup has increased and as a direct result of the introduction of the product to a Bristol medical specialist, a considerable use for it has developed purely on medical grounds through the agency of hospitals and clinics as well as National Health Insurance patients. Following these developments, the authors were approached on several occasions by doctors with the request that they should attempt to produce a pure black currant juice, as distinct from a syrup, with a palatable taste, balanced acidity and sweetness, and with a much higher vitamin content than a syrup or the beverage produced by diluting the syrup with water. Preliminary tests were carried out in 1938 and repeated in extended form in 1939.

Several interesting and authoritative opinions have been expressed in a trade journal connected with the Mineral Water Industry regarding the possibility of using fruit juice beverages or even purely synthetic products as vehicles for ascorbic acid, which could be incorporated in the beverage as a synthetic addition. Redgrove (1), in January, 1941, pressed for consideration to be given to the addition of ascorbic acid to mineral waters rather than to jams, the latter expedient having apparently been under discussion. The following issue of the same journal contained two further contributions on the same subject (2), (3). In the first of these, some doubt was expressed as to whether sufficient technical knowledge had been obtained to enable an authoritative statement to be made as to the stability of the ascorbic acid after its incorporation in the mineral waters. On the other hand, the writer of the second contribution claimed that ascorbic acid had been added to mineral waters with considerable success since 1938.

In view of these indications of interest by the mineral water and other industries in a subject of considerable national importance, it has been felt desirable to publish the results of the 1938-39 experiments here in very brief form.

Experimental.

In 1938 and 1939 fresh black currants were crushed and treated with pectin-decomposing enzyme for 48 hours and the expressed juice was filtered and treated in various ways. The gravities of the fresh juices were 1.042 in 1938 and 1.048 in 1939. The filtered, sweetened products were filled into white, half-pint glass bottles closed with crown-corks,

TABLE I.
EXPERIMENTS ON THE PRODUCTION OF BLACK CURRANT JUICÉ.

Expt. No.	Date of Making.	Treatment of Juice.	Analysis of Treated and Filtered Juice.			Analysis of Juice 24.2.41.			Condition of Stored Juice.	Flavour of Stored Juice.
			Specific Gravity.	Acidity as % Citric Acid.	Specific Gravity.	Acidity %	Ascorbic Acid mgs/100 cc.			
A. 38	July 1938	Sweetened to gravity 1.100. Filtered and pasteurised at 155° F. for 30 minutes.	1.100	2.70	1.099	2.18	81.2		Brilliant : no deposit.	Full, clean, characteristic aroma and flavour of black currants.
B. 38	"	Chalk added to reduce acidity to 1.3%.	1.042	1.30	1.042	0.74	77.0		Brilliant liquid. Heavy granular deposit ($\frac{1}{4}$ " thick).	Disagreeable taste of a saline type.
A. 39	July 1939	Sweetened to 1.100. Pasteurised. (Ascorbic acid = 149 mgs/100 cc.).	1.100	3.02	1.098	2.92	106.6		Brilliant : no deposit.	More intense in flavour and fresher aroma than A. 38.
B. 39	"	Sweetened to 1.100. Seitz E.K. filtered into sterile bottles.	1.100	3.02	1.094*	2.92	74.4		do.	Flavour altered on account of considerable aeration due to fermentation. Fruit flavour still predominant.
C. 39	"	Sweetened to 1.100. De-aerated and Seitz filtered into sterile bottles.	1.100	3.02	1.096*	2.86	75.2		do.	As for B. 39.
D. 39	"	Chalk added to reduce acidity to 1.65%. Slightly sweetened and pasteurised.	1.075	1.65	1.073	0.98	89.6		Brilliant liquid. Heavy granular fawn-coloured deposit.	Slightly saline taste but product still fully flavoured of the fruit.
E. 39	"	As for D. 39 but stabilised by Seitz filtration.	1.076	1.65	1.076	1.17	87.0		Brilliant liquid. Heavy granular white deposit.	As for D. 39.

* Fermenting.

and were stored without any protection from the light or from the very remarkable changes of temperatures which were experienced in Long Ashton during the period of the experiments.

The details of the experiments are given in Table I.

The results can be summarised as follows:—

1938 *Series.*

- (a) The flavour of the sweetened, pasteurised juice was excellent, and even after considerable dilution the beverage retained sufficient character to be readily identified as black currant. The neutralised juice was spoilt in flavour by the saline taste which was considered to be due to the presence of the calcium salts of the organic acids of the fruit.
- (b) The neutralisation of the acidity of the fresh juice did not affect the retention of ascorbic acid over a period of 32 months.

1939 *Series.*

- (a) The most attractive sample was A.39. The flavour was remarkably full and fresh, and the ascorbic acid was the highest in the series after 20 months' storage. The loss of ascorbic acid in this period was considerable, although the final figure is still much higher than for fresh citrus juices.
- (b) Fermentation appeared to cause an appreciable destruction of ascorbic acid (c.f. A.39, B.39).
- (c) Partial de-aeration did not appear to aid retention of the vitamin C.
- (d) Neutralisation did not appreciably affect the content of ascorbic acid.

These preliminary experiments indicate that it is possible to prepare black currant juices of a very attractive flavour and with average vitamin contents, after periods of 20 and 32 months, of approximately 95 and 80 mgs/100 cc. respectively.

The calculations of Drummond and Wilbraham for the vitamin C intake necessary for health for a normal adult (4), and the contribution to the British Medical Journal of Dr. Elliott (5), suggest that the requirements of vitamin C would be met by a daily consumption of about 100 cc. of black currant juice of the type and age indicated in the above report. Other work on this subject has shown that the ascorbic acid is lost at a gradual rate, and in view of this fact it may be safely assumed that juices as described above and stored for a maximum period of 12 months, would contain correspondingly greater quantities of the vitamin, thus necessitating the daily consumption of relatively smaller doses of the juice taken either as a medicine or as a beverage.

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THE CONTROL OF ANIMAL DISEASE— CONTAGIOUS ABORTION OF CATTLE.

By D. W. MENZIES, M.R.C.V.S.

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In the early days of the present war there was a decided lull in the number of enquiries concerning animal disease and very few pathological specimens were submitted. It appeared that farmers were either "marking time" or that they were much too busy with other branches of the industry, such as ploughing, to worry much about odd cases of illness that occurred among animals. As soon as farmers had more or less adapted themselves to the new conditions, the work in the laboratory reverted to practically pre-war standards.

In a former article, the writer stressed the fact that most of the conditions met with in the laboratory were diseases of fairly common occurrence, and that a large proportion of the losses of animals experienced by farmers were due to conditions known to science for many years, and that in many instances the condition might be cured if the disease was tackled early enough. A similar observation can be made concerning the work in the laboratory during the past year.

The loss by disease, particularly in the cattle industry, must be very great, and recently an effort has been made to assess on a national basis the wastage caused by the diseases of more common occurrence, *e.g.* abortion, mastitis and Johne's Disease. The investigations stressed the fact that a considerable proportion of these losses were due to failure on the part of farmers to take advantage of the knowledge which we already possess to keep such diseases under control.

Factors in the Control of Contagious Abortion of Cattle.

The Investigation Officer has undertaken in a number of herds blood tests for the control of Contagious Abortion, and in a few instances eradication of the disease has been accomplished. Where the disease has obtained a fairly secure foothold, it is probably not in the national interest to attempt eradication at the present time, but in order to attain some measure of control it is essential that the farmer should have a sound knowledge of the various methods which can be adopted. The disease is, of course, infectious, and is caused by *Brucella abortus*, which injures the lining membranes of the uterus. An animal which becomes infected and aborts, develops a lasting immunity to the disease, but this immunity varies with the individual, and it appears it is not developed

strongly if an animal is put to bull less than eight weeks after abortion has taken place. The disease is often introduced into a healthy herd by the addition to the herd of an in-calf cow which aborts, probably in an open field, and the other cows contract infection from the aborted foetus.

Eradication of the disease may be brought about by removing the infected cattle from the herd by the periodical testing of samples of blood from all the cattle. All newly purchased animals must be blood-tested at least twice before being drafted into the herd, and if they are near calving, they should not be introduced until blood-tested at least a week after calving. It is essential that good hygienic precautions should be taken to prevent the introduction and lessen the chances of spread of infection.

It has already been mentioned that infected animals develop their own immunity, and while there are numerous so-called cures on the market at the present time, the only method which has given definite evidence of its value under experimental conditions is live vaccine. By its use animals are infected with the disease at a time when no untoward results are likely to accrue, that is, animals are inoculated when they are not in calf, and it is essential that they be permitted a period of 8—10 weeks to develop an immunity before being sent to service. The objection raised to this method has always been that the disease is thus being disseminated, although the major loss from actual abortions is being prevented. More recently, vaccination has been carried out with strains of *Brucella abortus* which have been grown so long in the laboratory that they have lost the power of producing any disease, though they still possess strong immunising powers. This type of vaccine has also the advantage that it does not render an otherwise non-infected animal a reactor to the agglutination test. Also, animals which have been inoculated do not harbour the organism in their bodies, and as it is of low virulence, vaccinated animals are not a source of infection to non-infected cattle.

At the present time experiments are proceeding with the modified form of vaccination where young heifers 4—8 months of age are inoculated with live vaccine and kept separate from the main herd until they reach their first calving.

Within recent years, a type of abortion which occurs quite early in pregnancy has become much more prevalent. This condition is caused by a protozoan, *Trichomonas*, and while abortions most commonly occur at 6—8 weeks, the actual abortion is often overlooked by the farmer, and he considers that the condition is merely one of sterility. There is at present no method of inoculation suitable for dealing with *Trichomonas* infection. The disease can be brought under control by treating the affected animals, and not permitting them to breed for a month or two. Great care must also be taken with regard to the bull, which disseminates the disease.

Whatever the dairy farmer may decide to do to control abortion if it exists in his dairy herd, it is essential that he should first find out the cause of the abortions and how widespread it is in his herd before he decides on his policy.

While the practical application of our existing knowledge concerning abortion would greatly reduce the loss which is at present being sustained, a great deal could also be done in applying measures of control to many other diseases, not only of cattle but all other farm livestock. There is at present a drive to reduce loss brought about by disease in our animals by the co-operation of veterinary surgeons, agriculturists and farmers, and it is to be hoped that the problems involved will be tackled at an early date.

SOME WAR-TIME MILK PROBLEMS.

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It has been seen how, under war conditions, the national milk supply can fall to a dangerously low level. Some fall in milk yield was expected owing to the necessity of disposing of poor yielding cows in order to make better use of available stocks of feeding stuffs. But nature, by the prolonged drought of last summer when both the quantity and quality of pasturage was reduced, also played a big part in cutting down milk yields. Again, forage crops such as kale and roots were in some cases a complete or partial failure owing to the absence of moisture necessary for vigorous germination, and later because of the ravages of caterpillar. These factors robbed many farmers of a sufficiency of succulent food-stuff for autumn and winter use.

The lessons learned from last year's experience will, however, stand farmers in good stead in planning the cropping and the utilisation of the crops for the dairy herd in the coming year, when all practical steps must be taken to ensure as far as possible that the milk yield is maintained and even increased. That aim is and must remain the foremost consideration of the dairy farmer, and the success achieved will depend largely on the adoption of a sound cropping policy.

Cropping and Milk Production.

In 1941 the farmer will be in a better position to plan his cropping than he was for 1940. With more land coming under the plough a larger proportion can be earmarked for a succession of green crops and roots to tide over the dairy herd during the long period from late summer until the spring. Succulent foods fed judiciously at that time are invaluable, since not only do they supply essential nutritive material but they increase the palatability of the ration, create appetite and thus stimulate milk secretion. Moreover, they tend to improve the colour and quality of the milk.

Catch crops and forage crops from arable land will have to occupy another place in the feeding programme of the dairy herd, namely, to take the place of grassland lost to the plough. An acre or two under catch-crops will provide much more green material per acre than could be obtained from the same area under permanent pasture. The judicious use of such crops together with controlled grazing of the now restricted cow pasturage should serve to meet the major needs of the dairy herd throughout the summer.

The growing of a small acreage of protein-rich grain crops, *e.g.* peas, beans and linseed, will also receive more consideration in 1941; the inclusion of one or more of these crops in the rotation should be catered for in the national interest so as to alleviate the shortage of foreign protein concentrates.

The Importance of Quality in Milk.

Having provided for quantity attention must be given to milk quality, both as regards the chemical and bacteriological aspects. The suggestion has been advanced in some quarters that in war-time the quality of milk is not important. This is a fallacy. Milk as a food is not valued for its energy-giving properties—these can be provided equally well by other foods—but rather for its “protective” capacity in the mixed diet. In other words, its real value is derived largely from its protein, mineral matter and vitamin content. These chemicals are, to a great extent, linked closely with and included in the fat and solids-not-fat content by the estimation of which we measure the general chemical quality of any milk supply.

No advantage would be gained by allowing the fat and solids-not-fat to decline since the real nutritive value of the article would itself be reduced. Hence, as milk quality is, in the first instance, an inherited characteristic, breeding for quality as well as for quantity must remain a primary aim of the progressive dairy farmer. Any sacrifice of chemical quality in the breeding policy now may be reflected in the quality of the milk of the future herd for several generations. For those reasons, the necessity of continuing, and extending, the practice of recording the chemical quality of milk by the periodical testing of samples from cows whose milk yields rank them as desirable animals from which to build the future herd, is evident.

Bomb Shock and Milk Production.

One problem which has arisen as a result of the war concerns the probable effect of shock to cows, due to bombs falling in close proximity to dairy herds, on the quantity and quality of milk. Some investigation of this problem has been conducted but, since the location of bombing cannot be pre-determined, great difficulty has been experienced in collecting suitable material in the form of milk samples from affected herds immediately following the incident. Thus the data, at present, are limited.

Of the few cases investigated, however, it seems that the shock may have a tremendous effect in depressing the milk yield. This depression, which varies with the sensitiveness and reaction of the individual animal, is greatest for a few days immediately after the incident, after which the yield tends to increase; it is doubtful, however, if it ever returns to normality during that lactation. For instance, in one herd, on the day following the incident the yield of the cows was reduced by 15 gallons or approximately 35%, and after six weeks, although some increase had

occurred, the yield was still below the theoretical, calculated gallonage, some of the cows having prematurely dried off. In another herd the drop in yield on the day after the bombing amounted to 23%.

The influence on quality has been more difficult to assess because, in the cases investigated, no information was available as to the quality of the milk just prior to the incident. Samples, both individual cow and bulk herd milk, taken after the incident did not reveal any abnormality in terms of fat and solids-not-fat; the figures obtained were typical of those one would normally expect prior to the incident had the milk been sampled. There is, of course, a possibility that under certain circumstances, for example, when the bombing occurs just prior to milking time, some cows may withhold a considerable portion of milk, already secreted, at the next milking, and since the milk withheld is richest in fat it is feasible that the fat content of the milk produced at the first meal after the incident may be below normal. This effect would not be noticeable, however, at subsequent milkings.

Clean Milk.

Under war conditions when dislocation of transport facilities are to be expected, the period between production and ultimate consumption or manufacture of milk might be very considerable. As such disruption may occur during the warm summer months it is imperative that the milk producer should spare no effort to maintain, and in some cases, improve the bacteriological quality of his milk supply. It would be wasted effort to produce the maximum yield, if it were found that the milk when it reached its destination, was unfit for utilisation owing to faulty or careless methods of production. Super quality milk is not demanded, but an article is expected which, within reason, will remain wholesome until it is consumed, processed, or manufactured into dairy products. Milk of graded bacteriological standard will fulfil those conditions. This problem is being rendered more difficult in practice by several factors, the chief of which are the shortage of labour skilled in clean milk production, and the increasing use of milking machines.

Graded milk standard may be difficult to attain when an increasing number of workers, inexperienced in clean milk production have to be employed in the dairy. The only solution in these cases is the education of the workers on an extensive scale. Officers are available in every county for this purpose, and when tuition is sought it can be readily given.

As a partial solution to the labour problem many dairy farms have been forced to introduce machine milking. An indication of the extent to which machine milking has been adopted is shown from a recent survey conducted in connection with the production of graded milk in an area in this Province. In this particular area the average herd size is relatively small, the majority of the farms having less than 30 cows, and five years ago machine-milking was rare. Yet to-day, of the 224 graded milk producers with more than 15 cows in milk, 86 or 38% are now using machines.

In the same survey, the bacteriological results of hand and machine-produced milk were compared. These results, obtained from the examination of 833 samples taken during 1940, showed that whereas 26.7% hand-milked samples failed to attain graded milk standard, unsatisfactory machine-produced samples amounted to 36.7%. Or, when the sample results for the whole year for each farm were analysed it was seen that 36.5% of producers milking by hand maintained the required standard for graded milk for all samples taken as compared with only 22.1% in the case of producers using machines. This comparison again emphasizes the fact that more skill, diligence and knowledge of clean milk production is necessary where machine-milking is practised. It is well known that, with proper knowledge, skill and care, milk of satisfactory bacteriological quality can be produced equally well by machine as by hand. Much of the difficulty of obtaining good results with the machine is because it is not so easy to cleanse and sterilize the various parts of the plant whether it be a combine or bucket-type milker.

It is not always fully appreciated that the pipe-lines of a milking machine can be an excellent breeding ground for bacteria, and thus a serious source of bacterial contamination exists when the pipe-lines contain pabula in the form of fluid milky material or hard milk scale. But with proper and thorough cleansing methods, including the regular use of brushes, especially provided by the makers for that purpose, bacterial contamination can be avoided. In order to render a machine bacteriologically clean all milk residues must first of all be removed by washing in cold, then in hot water containing detergent. In this connection it should be emphasized that one of the secrets of keeping the machine physically clean is to flush thoroughly with a liberal supply of cold water immediately—not an hour after—milking has finished. This action prevents milk residue from drying and forming scale which, once established, is so difficult to remove.

So far as sterilization is concerned, too often the rubber parts are steamed only once weekly. While such infrequent chest or jet steaming may suffice during cold weather it is insufficient in summer. The plea voiced in support of such infrequent sterilization is that the rubbers will deteriorate more rapidly if daily steaming is practised. This is true, but it is obviously desirable in the producer's own interest and imperative in the war-time national economy that an additional set of rubbers be used rather than to produce milk of inferior bacteriological quality which may become sour or tainted before it can be utilised.

FARM ECONOMICS IN 1940.

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In re-reading the article which appeared in the 1939 Report* it occurred to the writer that in spite of frequent air raids on Bristol and the difficulties that farmers have experienced, the work in agricultural economics during 1940 has not been interrupted to anything like the extent it was at first anticipated. The farmers co-operating in the various investigations have recognised the importance of consistent record keeping in abnormal times such as these, and have done much to facilitate the prompt compilation of the necessary statistics relating to agricultural conditions in the economical and financial sphere.

Briefly it can be stated that our present work is to feel the economic pulse of the agricultural industry and to register changes as they occur. The Ministry of Agriculture and the Ministry of Food are informed periodically of such changes and are thereby kept fully informed about current conditions in farming. Thus is built up a large mass of statistics from which it is not difficult to ascertain in what directions the agricultural economic machine needs adjustment to enable maximum output to be obtained.

This ultimate analysis can only be made after the careful collection and tabulation of facts. In some directions it is possible to obtain a limited number of facts from every farm, but in other directions it is only possible to obtain facts from a proportion of the farms. This latter method thus makes use of a "sample" investigation and it is the task of the economist and statistician to interpret these facts in such a way that they can be safely applied not only to the sample, but to all the farms in the geographical area from which the sample is drawn.

Unfortunately, it is not possible to give a completely detailed statement up to date because of the time lag which is bound to occur when summarising large quantities of statistics. For instance it is not possible to say now, except in general terms, what the financial position of farmers was for the year 1940. One very good reason for not being able to give details is that few farm accounts run for the calendar year; they nearly always run for what is known as the financial year, which varies according to locality. From Ladyday to Ladyday, or from Michaelmas to Michaelmas are the most usual financial years, but they may, and do, run from various other dates.

* C. V. Dawe, "How the War may affect Production Costs," pp. 145-148.

It is, however, known that 1939 was a better year financially than 1938, as the tabulated accounts prove, but it is expected that 1940 will show a somewhat worse position than 1939, although of course different types of farms will be affected in different ways. It will probably prove to be the case that farms with a fair proportion of arable land will make a better showing than those which are largely grassland and depend a great deal on livestock. This is indeed the case when comparison is made between the years 1938 and 1939, for while grass farms and mixed farms showed a rise in net income between 1938 and 1939 of approximately 13/- per acre, the mainly-arable farms showed a rise of slightly more than twice that amount. It is known, too, that over all types of farms the improved position was due to the fact that income increased by 13 per cent., whereas costs increased by only 5 per cent. Thus speaking in terms of index numbers we can say that compared with 1938, the index of production in 1939 was 113, while that of costs was 105. It remains to be seen how the year 1940 will alter these indices. This is, of course, a very simple example of index numbers and they can be multiplied almost *ad infinitum*. It is suggested, however, that farmers themselves should make use of their own farm accounts in order to compile a series of such indices. They form an invaluable record of the years that have passed and can be usefully employed as a guide to improved farm management in the future, for it is often not the absolute differences that matter so much as the relative differences. To put it in another way, it is the margin that counts, for the ultimate net profit on a farm is the combined result of marginal differences. In war time, with sudden changes in prices of requisites such as feeding stuffs, fertilisers and implements, to say nothing of labour, or in the prices of products, it is extremely important that farmers should keep a systematic record of such changes.

The influence of the various kinds of subsidies and rebates upon farm production must not be ignored. There is no doubt that such Government assistance has made considerable difference in the financial position of farms. In 1939 these subsidies averaged 12/6 per acre, as compared with 7/- per acre in the previous year, and they accounted for 6 per cent. of the farm income.

There have of course been some modifications in 1940, but unfortunately the effect upon the agricultural economy of the country cannot yet be measured with any degree of precision. The interaction and counter-action of the various forms of Government assistance and control, and their incidence, comprise in themselves a very interesting study. Such a study may appear to some farmers to be merely an academic exercise, but it is clear upon further consideration that the relative influence and importance of the various kinds of assistance or stimulus do ultimately affect the whole balance of English agriculture.

At the outbreak of the war three new schemes were started: one to record changes in the actual prices paid by farmers for feeding-stuffs, the second to discover changes in the numbers of men employed and in

the wage rates and earnings received by them, and the third to ascertain changes in the cost of production of milk for shorter periods than hitherto. All these schemes are running on a monthly basis, and every endeavour is made to complete the material within ten days of the close of the month, or at least within the following month.

At present there are 42 farmers co-operating in the feeding-stuffs scheme, 35 in the labour scheme, and 28 in the milk scheme.

Changes in prices paid for feeding-stuffs are recorded for some 25 feeding-stuffs each month. The prices recorded include haulage costs charged to the farmer, but discounts are ignored. Selected figures are provided in Table I.

Of the 35 farms for which particulars of labour are available, 25 are complete from the beginning of the war to the end of 1940. They are analysed in two groups, one consisting of 14 grass dairy farms, and the other consisting of 11 semi-arable, mixed farms. In Table II are given figures showing the changes in contract wage rates and earnings per man for 24 male workers over 21, employed throughout the whole period on the 14 grass dairy farms. The contract wage rate includes the value of all perquisites such as free milk and free cottages, also the workers' share of the insurance. Regular weekly overtime is included here, so that the difference between the contract wage rate and earnings is entirely accounted for by seasonal overtime, bonuses or short time.

The calculations for the 11 semi-arable farms are not yet complete but they will show the same kind of result. Other groups of farm results are being analysed for similar data.

One must, of course, always distinguish between average results over a group of farms and the variations found from farm to farm. One of the most prominent features of all work in agricultural economics is, in fact, the wide range in any series of statistics relating to farming expenditure and output. For example the costs of production of milk in the counties around Bristol have varied as shown in Table III during the last six years.

The farmers have all kept weekly records of costs and production on the same kind of record sheet, which has been scrutinised when received by the University and queries raised whenever necessary. It is no criticism of these figures to say that they are untrue or impossible, for it should be understood that in giving the range of costs the intermediate results lie fairly evenly along the scale or range of costs. That is to say, at any given point along the range farmers will be found to be producing milk at, say, only one-tenth of a penny per gallon more or less than the next, and it would be either a bold or foolish man who attempted to segregate the co-operating farmers into the efficient and the inefficient. This brings into prominence the great difficulty of fixing prices in accordance with the cost of production. In fact price fixation by the

Government or any other body is always fraught with risks both on the supply and the demand side. One may easily ask what is cost of production, and receive no satisfactory answer. Thus the policy of price fixation can only be justified in a time of emergency.

TABLE I.

PRICES PER CWT. PAID BY FARMERS FOR SELECTED FEEDING STUFFS.

	<i>Dairy Cake.</i>	<i>Pig Meal.</i>	<i>Bran.</i>	<i>Flaked Maize.</i>	<i>Barley Meal.</i>
	<i>s. d.</i>	<i>s. d.</i>	<i>s. d.</i>	<i>s. d.</i>	<i>s. d.</i>
Winter 1938-1939 ..	8 2 $\frac{1}{2}$	?	7 11 $\frac{1}{4}$	7 9 $\frac{1}{4}$	?
Summer 1939 ..	7 8 $\frac{3}{4}$	?	6 4 $\frac{3}{4}$	7 5 $\frac{1}{2}$	?
November 1939 ..	8 7	9 0 $\frac{3}{4}$	7 1 $\frac{1}{2}$	8 9 $\frac{1}{4}$	7 11
December 1939 ..	8 8 $\frac{1}{4}$	9 4 $\frac{1}{4}$	7 3 $\frac{1}{2}$	8 7 $\frac{1}{4}$	7 11 $\frac{1}{2}$
January 1940 ..	9 10 $\frac{1}{2}$	10 10 $\frac{3}{4}$	8 0 $\frac{3}{4}$	11 6 $\frac{1}{4}$	9 4 $\frac{1}{2}$
February 1940 ..	10 9	11 11 $\frac{3}{4}$	8 0 $\frac{1}{2}$	11 2 $\frac{1}{4}$	10 7 $\frac{1}{2}$
March 1940 ..	11 1 $\frac{1}{4}$	12 9	8 2 $\frac{1}{2}$	11 7	11 2 $\frac{1}{4}$
April 1940 ..	11 0 $\frac{1}{4}$	12 7 $\frac{3}{4}$	7 8	11 2 $\frac{1}{2}$	?
May 1940 ..	11 2 $\frac{1}{4}$	12 4 $\frac{1}{2}$	8 6 $\frac{3}{4}$	12 8 $\frac{1}{4}$	11 1 $\frac{1}{4}$
June 1940 ..	11 10	12 7 $\frac{1}{2}$	10 0 $\frac{1}{2}$	13 3 $\frac{3}{4}$	12 1 $\frac{1}{2}$
July 1940 ..	11 8 $\frac{1}{2}$	13 4 $\frac{1}{4}$	10 0 $\frac{1}{2}$	13 7 $\frac{1}{2}$	12 10
August 1940 ..	11 8 $\frac{1}{4}$	14 7	9 6 $\frac{1}{2}$	14 1	17 11 $\frac{3}{4}$
September 1940 ..	12 4	14 9 $\frac{1}{2}$	10 5 $\frac{1}{2}$	13 10	18 0
October 1940 ..	12 7 $\frac{1}{2}$	15 6 $\frac{3}{4}$	10 4 $\frac{3}{4}$	14 0 $\frac{1}{2}$	18 5 $\frac{1}{2}$
November 1940 ..	12 1 $\frac{3}{4}$	15 7	9 6 $\frac{1}{2}$	13 0	17 8 $\frac{1}{4}$
December 1940 ..	13 3 $\frac{1}{4}$	16 1	10 3 $\frac{1}{4}$	13 4 $\frac{1}{4}$	17 9

TABLE II.

CHANGES IN THE WAGE RATES AND EARNINGS PAID TO 24 MALE WORKERS OVER 21
EMPLOYED ON 14 GRASS DAIRY FARMS FOR THE WHOLE OF THE PERIOD,
SEPTEMBER 3RD, 1939, TO DECEMBER 28TH, 1940.

<i>4 Weeks ending.</i>	<i>Contract Wage.</i>	<i>Earnings.</i>
	<i>£ s. d.</i>	<i>£ s. d.</i>
30 September, 1939 ..	2 4 0	2 4 0
30 December, 1939 ..	2 5 0	2 4 0
27 January, 1940 ..	2 5 0	2 4 0
24 February, 1940 ..	2 6 0	2 2 0
23 March, 1940 ..	2 7 0	2 6 0
20 April, 1940 ..	2 7 0	2 7 0
18 May, 1940 ..	2 8 0	2 8 0
15 June, 1940 ..	2 8 0	2 15 0
13 July, 1940 ..	2 12 0	3 1 0
10 August, 1940 ..	2 18 0	3 4 0
7 September, 1940 ..	2 18 0	3 1 0
5 October, 1940 ..	2 18 0	2 18 0
2 November, 1940 ..	2 19 0	2 19 0
30 November, 1940 ..	2 19 0	2 19 0
28 December, 1940 ..	2 19 0	3 0 0

TABLE III.

VARIATIONS IN THE COST OF MILK PRODUCTION PER GALLON.

<i>Winter.</i>	<i>Lowest Cost.</i>	<i>Highest Cost.</i>
1934-5	8d.	20d.
1935-6	4 $\frac{3}{4}$ d.	17 $\frac{3}{4}$ d.
1936-7	5 $\frac{1}{2}$ d.	17d.
1937-8	7d.	20d.
1938-9	7 $\frac{1}{4}$ d.	20d.
1939-40	6 $\frac{1}{2}$ d.	23 $\frac{1}{2}$ d.
<i>Summer.</i>		
1935	3 $\frac{3}{4}$ d.	13d.
1936	4d.	13 $\frac{1}{2}$ d.
1937	4d.	12d.
1938	4 $\frac{1}{4}$ d.	12 $\frac{3}{4}$ d.
1939	3 $\frac{1}{4}$ d.	12d.
1940	4 $\frac{1}{2}$ d.	14 $\frac{3}{4}$ d.

WAR-TIME ACTIVITIES IN AGRICULTURAL CHEMISTRY. THE LIME, PHOSPHATE DEFICIENCY SURVEY.

By E. L. SMITH, B.Sc.,
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The necessity for soil analysis in war-time was the subject of an article published in this Report last year, and a brief reference was made therein to the results obtained from soil surveys. The present paper summarises some of the more important observations noted during the past year's work in connection with the Lime, Phosphate Deficiency Survey.

The initial object of this investigation, which commenced in October, 1938, was to examine the lime and phosphate status of soils collected from areas where fertility was known to be low. At the outbreak of hostilities the work was temporarily suspended, but it was soon realised that, in view of the necessity for maximum production from all agricultural land, the results obtained from this survey should form a valuable contribution to the war effort. With this renewed interest, activities were recommenced on somewhat modified lines.

Areas Surveyed in 1939-1940.

Owing to the uncertainty of developments in the war situation it was decided to confine the initial work to areas situated just outside the Bristol boundary.

On the Somerset side, a beginning was made at Barrow Gurney; then, proceeding field by field in a north-westerly direction, a broad belt of land was covered terminating at Portbury. In addition, a considerable acreage of typical Mendip country, which included the farms in the parishes of Chewton Mendip, Priddy and Charterhouse, was surveyed.

In Gloucestershire, operations commenced at Stapleton and Stoke Gifford and extended as far as the edge of the Cotswolds at Codrington and Tormarton.

All soils in this survey are derived from materials from sedimentary rocks of older geological formations, the most recent rocks being of Oolitic origin.

Analytical Determinations.

Past experience has shown that of the many analytical determinations possible, those which convey the most practical information to the farmer are the lime requirement (or alternatively calcium carbonate content in

the case of a calcareous soil), and the percentages of phosphoric acid (P_2O_5) and potash (K_2O) which are present in the so-called "available" form, *i.e.* soluble in a 1% solution of citric acid. For statistical purposes, the pH figure denoting the intensity of acidity, is also recorded.

In a survey of this type analytical data alone would lose much of their significance unless accompanied by such details as:—

- (a) Previous history of the field.
- (b) Recent manurial treatment or liming.
- (c) Failures or difficulties encountered.
- (d) Drainage.
- (e) Soil texture.
- (f) Type of herbage and species of weeds.

Observations under these headings were recorded for 2,445 fields.

The Lime Status of the Soils.

Analysis revealed that 1,994 samples, or 82% of the total number collected, were lime deficient. From Table I it will be seen that even within an area of a square mile or so the amount of the lime requirement can vary within very wide limits. The data shown represent grassland which has received neither lime nor artificial fertiliser dressings, and has not been disturbed by the plough for at least 20 years.

TABLE I.
RANGES OF LIME REQUIREMENT FOUND IN VARIOUS LOCALITIES.

Geological Formation.	Locality.	Lime Requirement in cwt. per acre of Limestone.	
		Lowest.	Highest.
Mountain Limestone	Charterhouse and Priddy	40 cwt.	132 cwt.
" "	Failand and Portbury	4 cwt.	78 cwt.
Keuper Marl	Wapley and Westerleigh	24 cwt.	106 cwt.
Lower Lias	Dodington	18 cwt.	96 cwt.

In view of the existence of such wide variations in the lime requirement, farmers should make a point of having a soil analysis made to ascertain the correct amount and the most suitable type of lime to apply.

In regard to the Mendip Hills, the soils derived from Mountain Limestone and which are light in texture were found in every case to require lime; frequently, the requirement exceeded 5 tons of limestone per acre. A similar type of soil occurs over parts of the Failand area where the lime requirements were relatively much lower; actually a dressing of 2 tons of limestone per acre would more than meet the needs of the

majority of the fields in this area. In both districts high lime requirement figures were always found in association with poor types of grass and a dense "mat" of dead herbage.

At Westerleigh, and again at Stoke Gifford, medium loams derived from Keuper Marl are to be found and are more productive than the older Mountain Limestone soils. Analysis proved that lime deficiency was widespread and in a few cases almost as acute as on some of the Mendip land when viewed in terms of the lime requirement figures.

Somewhat different conditions were observed on the heavier soils derived from the Lower Lias formation, which cover several hundred acres lying between Chipping Sodbury and Dodington and also a smaller area at Stoke Gifford. The surface soil of very old pastures and meadows was invariably found to have been depleted of its calcareous material by leaching and, in consequence, analysis revealed lime requirements which varied in amount according to the extent of this action. On the other hand, all arable land in the district was observed to be well provided with the native Lias Limestone which, as a result of the action of the plough and other implements of cultivation, is retained and well distributed throughout both surface and sub-soil.

"Available" Phosphate (1% citric acid extract).

As plant roots can only obtain and utilise certain of the phosphorus compounds in the soil, one of the problems of the soil chemist is to decide if there is sufficient phosphate present in the "available" form to meet all the requirements for satisfactory growth, or whether an application of a suitable phosphatic fertiliser would be likely to yield a profitable response.

On arable land poor "availability" is felt most of all by those crops which have weak or poorly developed root systems, *e.g.* swedes and turnips, whilst on grassland growth of wild white clover is especially impaired.

Previous experience of the soil types encountered under this survey has led to the conclusion that under good farming conditions there should be a minimum of 0.018% "available" phosphoric acid (P_2O_5) and a useful response from phosphatic manuring can often be obtained even where the figures are much higher by judicious stock management. On the Mountain Limestone formation soils rarely came up to this standard and were usually found to be of the order of 0.010% with two examples as low as 0.004%. A striking difference was found between the soils of the Mendip Mountain Limestone and those of the adjacent region of Lower Lias at Chewton Plain. All the latter soils were noted as having unusually high phosphate "availability" and the amount sometimes exceeded 0.100%. Comparison figures are shown in Table II. A marked increase in productivity is also typical of these heavier soils.

TABLE II.

RANGES OF PERCENTAGE "AVAILABLE" PHOSPHATE FOUND IN VARIOUS LOCALITIES.

Geological Formation.	Locality.	Percentage "Available" Phosphoric Acid (P_2O_5).	
		Lowest %.	Highest %.
Mountain Limestone.. ..	Chewton Mendip	0.004 (72)	0.029 (106)
Lower Lias (Surface soil acid)	Chewton Plain	0.029 (74)	0.143 (54)
Keuper Marl	Westerleigh	0.008 (68)	0.144 (42)*

* A 2 acre field intensively folded by poultry.

Lime requirement figures are shown in brackets.

"Available" Potash (1% citric acid extract).

Although the survey was not intended to include an investigation of the potash status of the soils, it has long been suspected that there are potash deficient areas in the Bristol Province. The survey afforded a convenient means of enquiry into this point, and thus "availability" of potash was determined on all samples collected. Actually, no extensive area of deficiency was confirmed within the confines of the survey, but in each of the localities visited there was always found to be one farm at least where all fields yielded percentages far below the standard for the particular soil type.

Generally speaking, the Mendip soils showed better "availability" of potash than of phosphate, and the higher percentages were often observed to be associated with either bracken infestation on the rough grazing, or with a dense rabbit population.

Considering each farm independently, fields mown each year were usually found to have poorer potash "availability" than those which were kept regularly for grazing.

Importance of Correct Balance between Phosphoric Acid and Potash.

A point which is often overlooked is the necessity for preserving a correct balance between the "available" amounts of the two nutrients. Farmers have occasionally expressed disappointment and dissatisfaction with the results they have obtained from applications of artificial fertilisers and from phosphate dressings in particular. In many of these instances the full effect of the phosphate was lost owing probably to poor "availability" of soil potash. A high proportion of the samples showed this type of imbalance.

Organic Matter.

Farmers will agree that it is most essential that soils should contain adequate supplies of organic matter and that regular applications of dung are necessary. On many of the soils of lighter texture, productivity

was often found to be impaired as a result of rapid drying during spells of drought; the majority of these soils contained a relatively low percentage of organic matter.

Drainage.

Manures are wasted on land where persistent water-logging has encouraged a coarse and weedy herbage. Inadequate drainage spoils first-class land just as much as it does poorer land. Careful attention was paid to the drainage conditions of the fields covered by the survey, and the following notes are considered important:—

(a) *The Somerset Area.* Most of the fields in the vales were observed to be fairly well drained, whilst the whole of the Mountain Limestone districts and most of the adjacent smaller areas of Dolomitic Conglomerate and Old Red Sandstone had natural free drainage. The worst examples of impeded drainage were seen on the low-lying ground forming the banks near the mouth of the Avon.

(b) *The Gloucestershire Area.* The entire region of heavier soil extending from Chipping Sodbury to Dodington was observed to be very badly in need of drainage. The grasses consisted mostly of bents, sweet vernal and often tussock grass (*Aira caespitosa*) in association with a high weed population, which included such water-loving types as sedges, rushes, adder-tongue fern, marsh marigold and bitter cress. In the past, deep drains were laid and no doubt many of these would still function if the outlets were cleared; at the same time there did not appear to be sufficient ditches or water courses to deal successfully with the whole of the district.

As a result of persistent wetness it was found that the calcium carbonate had been washed out from the surface soil of the older pastures. The Lower Lias soils of Chewton Plain which are, in comparison, much drier, have not suffered so severely from this leaching action.

Conclusions.

The data obtained as a result of the survey leads to some important conclusions which should be given prominence in view of the necessity for maximum production from all agricultural land.

(a) *Drainage.* Poor drainage is one of the biggest obstacles to successful farming on clay land. It was found that attention was urgently required on one very extensive area at Dodington, as well as on several smaller areas consisting of a few fields only.

Farmers and land-owners are reminded that grants are offered by the Ministry of Agriculture towards the cost of all approved work in connection with mole and tile drainage, reconditioning of any existing drainage systems which have ceased to operate satisfactorily, also reconditioning of farm ditches, streams and water courses. Furthermore, work carried out by drainage authorities is also eligible for grants. The Ministry of Agriculture contributes up to 50% of the cost of all work

done, with maxima of £1 and £7 10s. per acre in the case of mole draining and tile draining respectively. If necessary, the full cost of the work will be borne immediately by the Ministry, and a farmer or landowner allowed up to three years in which to pay his contribution.

(b) *Liming.* The survey has revealed that much more attention must be devoted to liming than has been the case hitherto. Considering each area as a whole, the quantity of lime which has been applied since the Land Fertility Scheme came into operation in 1937 represents only a very small fraction of the amount actually required for optimum conditions.

It is obvious from the data that insufficient use has been made of the facilities offered to farmers for obtaining supplies of lime. It should be pointed out that any form of lime suitable for agricultural land, and obtained from approved suppliers, is eligible for a grant in respect of the cost of the material and its transport to the farm, provided that the quantity is not less than 2 tons. Under these terms the occupier of land pays only one-half of the cost of the material delivered to his premises.

(c) *Phosphate Deficiency.* The frequent instances of deficiency of "available" phosphate which were encountered could have been remedied had greater use been made of the subsidy on basic slag. It has been frequently urged that a definite programme of slagging should form part of the farming policy wherever basic slag is known to be effective.

(d) *Potash Deficiency.* Improvement in the "available" potash status of the soil could be obtained on many farms by giving careful attention to grazing management. Also, by incorporating the maximum amount of litter when making farmyard manure, the wastage of potash through loss of urine could be minimised.

Supplies of potash fertilisers are obtainable for application to land where potatoes, sugar beet, flax and market garden crops (other than fruit) are to be grown. It is incumbent upon farmers to make sure that these crops receive a suitable fertiliser dressing containing potash, especially if the soil is suspected of being potash deficient. In certain cases, potash fertilisers can be obtained for application to the lighter soils on production of a certificate signed by a member of the County War Agricultural Executive Committee.

(e) *Organic Matter.* Larger percentages of organic matter in the lighter soils are necessary. In this direction, consideration should be given to the possibilities of green manuring.

(f) *Periodic Soil Analysis.* There is a practical point which should be impressed upon all farmers in regard to soil analysis. If carried out periodically as a control measure, the analytical data should provide invaluable information regarding the effectiveness of any manurial treatment which has been given, and indicate the lines on which future policy should be directed. The Agricultural Advisory Service which is free of cost is at the disposal of all farmers for this purpose.

REPORT ON ADVISORY WORK, 1939—1940.

The period covered by the Report comprises the first year of the war, and it was to be expected that the Advisory Service would show some differences in working from the pre-war routine. The first three months of the war witnessed a great change-over in farming activities, and during that period farmers were often too concerned with domestic problems calling for immediate action, in an atmosphere of change, to draw upon the facilities offered by the Advisory Service. This resulted in a temporary lull in advisory calls in most subjects, but as the situation has become more clear, following the initial period, advisory requests, especially as related to cropping problems, have shown a tendency to increase above the pre-war level.

The abnormally cold spell in January and February 1940 also caused a slackening in advisory work, for not only were farm operations often at a standstill but the Advisers were unable to make advisory visits due to the difficulty experienced in travelling within the Province.

It will be clear from the separate reports which follow that war-time activities in certain subjects are still in a somewhat unsettled condition and will be liable to further sharp changes to meet the new situations which are likely to arise from the intensification of the agricultural war effort.

The number of enquiries shown in the statistics for 1940, which are directly comparable with 1939, shows an increase of 146 in a record total of 7,862.

The main features in the totals accounting for this change are large increases for Agriculture and Agricultural Chemistry (+ 364) and Domestic Preservation of Fruit and Vegetables (+ 427), to which subjects official war-time policy has given a great stimulus, and a large decrease in Dairy Bacteriology (— 726), which experienced a sharp setback in the early stages of the war and in which a considerable re-orientation of work has occurred.

As usual, no statistics are included for Agricultural Economics. In this subject the work during the period has been mainly of a special character in close collaboration with the Ministry.

During the year it became necessary, for financial reasons, to make the decision to reduce the scope of the work of the Poultry Pathology Section. The services of the Poultry Pathologist were terminated at the end of September, 1940, since when the Veterinary Investigation Officer has supervised the work which has been retained.

The statistics for 1940 in the table below include 222 enquiries dealt with by the Poultry Pathologist on behalf of the Veterinary Officer. In addition the Section carried out 77,205 Blood Tests and 1,865 Post-Mortem Examinations.

The statistics refer to thirteen subjects, four at Berkeley Square Centre and nine at Long Ashton.

The nett increases and decreases for the various subjects at the two centres are as follows :—

Berkeley Square. Total decrease, 307 : Agriculture and Agricultural Chemistry (+ 364) ; Dairy Bacteriology (— 726) ; Veterinary Science (+ 64) ; Poultry Pathology (— 9).

Long Ashton. Total increase, 453 ; Cider (+ 47) ; Cider Instruction (+ 45) ; Fruit Products (+ 65) ; Pomology and Vegetable Culture (+ 12) ; Horticultural Chemistry (+ 43) ; Economic Entomology (— 49) ; Economic Mycology (— 97) ; Insecticides and Fungicides (— 40) ; Domestic Preservation (+ 427).

At the Berkeley Square Centre the Survey Work under the Land Fertility Scheme has continued to increase and further expansion of the work has been provided for in 1941 by the Ministry.

The Counties of Dorset, Monmouth and Worcester again participated in the Cider Instruction Scheme.

The Plant Pathologists continued their Spray Programme Service to Fruit Growers throughout the Province. Proposals for the extension of present facilities under the Scheme in Worcestershire have been made through the Horticultural Sub-Committee of the County War Agricultural Executive Committee.

The post of Willow Officer, vacated by Mr. Hutchinson on his retirement on 31st July, 1939, has not been filled by the Ministry, and hence advisory work on Willows since that time has been restricted to questions of Pest and Disease Control.

The Advisory work during the year covered the following subjects :— Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Poultry Pathology, Cider, Cider Instruction, Fruit Products, Pomology and Vegetable Culture, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetables.

The number of enquiries submitted to the Department during the past six years are summarised in the following table :—

	Year ending September 30th.					
	1935	1936	1937	1938	1939	1940
Gloucester (including Bristol)	1602	1622	1730	1775	2264	1965
Hereford	360	497	275	337	556	182
Somerset	1119	1138	1118	1459	1117	1403
Wiltshire	1365	848	1007	1328	1586	970
Worcester	528	509	360	520	677	656
Other Areas	1571	1872	1963	1813	1516	2686
	6545	6486	6453	7232	7716	7862

The figures are shown separately in the table for the five counties which comprise the Bristol Advisory Province and for Other Areas. The latter category includes Devon and Monmouth, both of which contribute annual grants to the Long Ashton Institute, and Dorset which participates in the Cider Advisory Scheme.

Staff Changes and Appointments.

Agriculture and Agircultural Chemistry. Mr. R. A. Pullin, Senior Fieldman under the Lime, Phosphate Deficiency Survey of the Ministry of Agriculture, resigned on the 6th October, 1939, to take up farming on his own account.

The vacancy was filled by Mr. F. J. Marshall, N.D.A., previously Assistant Fieldman.

Agricultural Economics. Mr. E. Dawson, B.Sc., N.D.A., N.D.D., was appointed Student Assistant in the Agricultural Economics Section on April 15th, 1940, in succession to Mr. P. J. O. Trist, who resigned on the 27th January, 1940, to take up an appointment at the East Anglican Institute of Agriculture, Chelmsford.

Mr. H. J. Steer, B.Sc., was appointed Technical Assistant in Agricultural Economics on the 2nd September, 1940, in succession to Mr. C. J. Harwood, who resigned on the 24th August, 1940, to take up an appointment with the National Smelting Company, Limited, Avonmouth.

Poultry Pathology. In view of the policy of the Government concerning the reduction of poultry flocks throughout the country, it has unfortunately been necessary to dispense with the services of Miss Duncan, the Poultry Pathologist, from 1st October, 1940. Nevertheless, arrangements have been made whereby the Poultry Pathological Laboratory will still function, although on a somewhat reduced scale. The Laboratory will be under the direct control of Mr. D. W. Menzies, the Veterinary Investigation Officer, and the Ministry has made provision for him to have the required assistance in order that advisory work, blood tests and post-mortem examinations in respect of poultry may be continued.

Economic Entomology. Mr. S. H. Bennett, B.Sc., was appointed on the 1st May, 1940, to assist the Advisory Entomologist in the Wireworm Survey work undertaken in conjunction with the Ministry of Agriculture Plant Pathological Laboratory.

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